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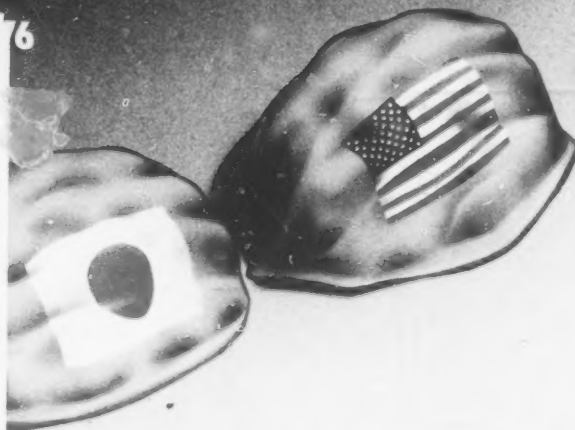
Electronic Business®

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THE NEW SHELL GAME

Where was this U.S.
chip *really* made?



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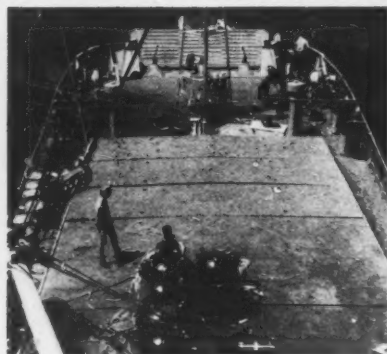
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Electronic Business

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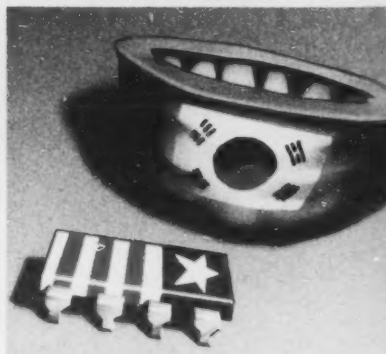
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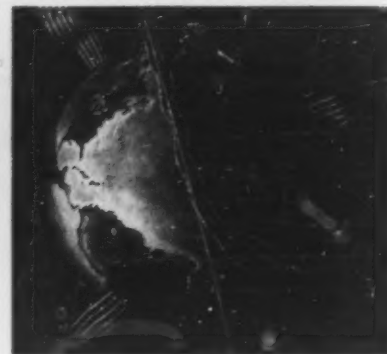
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As computers go, semiconductors used to go

But in 1988, the semiconductor market draws plenty of strength from other markets, such as automobiles

Jack Beedle turned into an optimist with the new year. He upped his forecast for the U.S. semiconductor market in 1988 from 11% to 17%. His optimism is based on a negative factor: the stock market crash of last October. Or, more precisely, on the way the U.S. economy has weathered what he calls "the October 19 tsunami." Beedle sees the economy shifting from consumer demand to industrial demand.

"Exports are up, the dollar is down, computer production went up sharply in the last quarter of 1987," says the president of market research firm In-Stat Inc., which specializes in the semiconductor market. In particular, Beedle found great encouragement in the strong showing by the U.S. market for semis in the last quarter of 1987. At \$2.8 billion, it was the highest since the last quarter of 1984, almost 30% higher than the year-earlier quarter, and it pushed 1987 to top the previous year by 22%.

Fourth quarter results by computer and semiconductor companies alike confirm Beedle's newly found optimism. Sun Microsystems Inc. doubled its sales in that quarter; its momentum may push Sun's sales over \$1 billion this year. Seagate Technology, which is well on its way to that financial mark, grew by 32%. Among the chip makers, the ASIC manufacturers continued to outperform the rest of the field. One of the leaders in that market, VLSI Technology Inc., saw its sales increase by 37% in that quarter, although that was below the remarkable 54% it registered by finishing 1987 at \$172 million. And Silicon Systems Inc., an ASICs manufacturer and a big supplier of chips to Seagate, registered 48% sales growth for the quarter.

By contrast, Cahners' senior economist Elizabeth Baatz sees trouble where Beedle draws hope. While her forecast for the U.S. semiconductor market has been all along more opti-

mistic than In-Stat's — her latest is for a 28% increase this year — Baatz is concerned with the 18.5% drop that the U.S. Bureau of the Census reported in seasonally adjusted orders for computers and business equipment for last November.

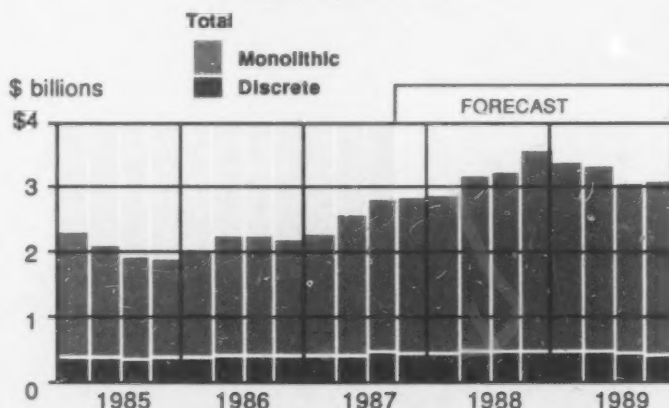
Actually, even Beedle's forecast has a negative side. While U.S. chip makers are glad to see him optimistic

("They're not used to it," he quips), the 17% he forecasts for the U.S. market is less than the growth he sees for the whole world. He has upped his growth prediction for the worldwide market from 10% to 21%. Since the Semiconductor Industry Association, as well as the market watchers, measure the market in dollars, some of that increase derives from the continued strength of the yen. But not all; the rest comes from: Hong Kong, Korea, Singapore and Taiwan.

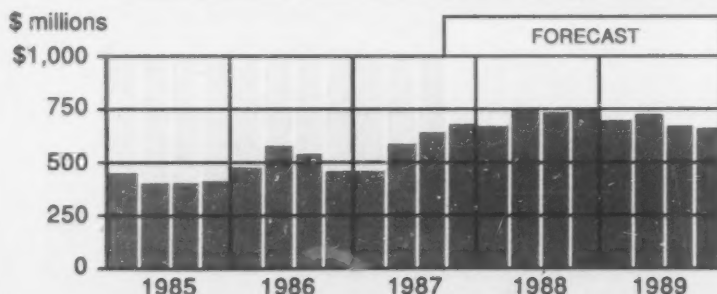
ALBERTO SOCOLOVSKY

Semiconductors

U.S. semiconductor sales

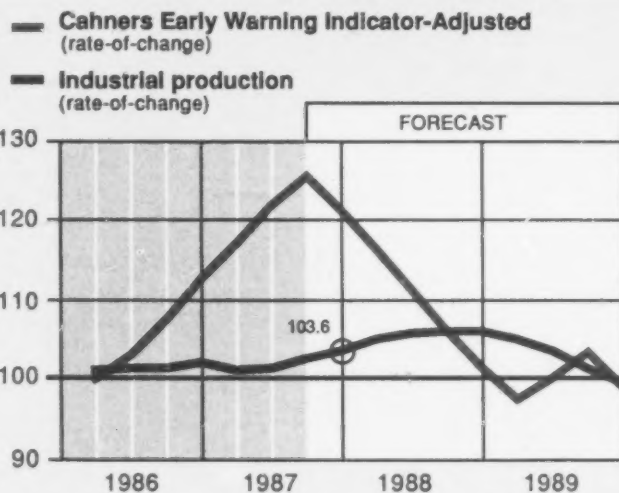


U.S. semiconductor distributor shipments



Historical data: Semiconductor Industry Association; Forecast: Cahners Economics

Economic indicators



Steady growth expected

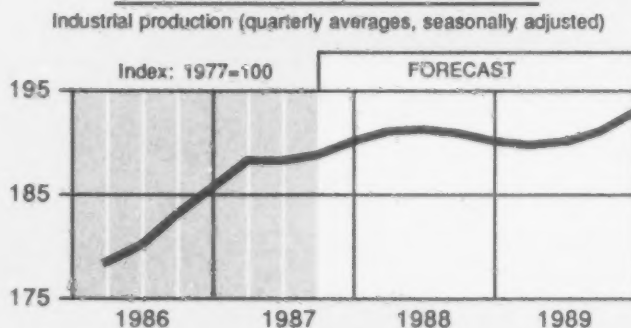
The United States Index of Industrial Production, a coincident indicator of the U.S. economy, has been climbing steadily since the summer of 1986. During 1987's third quarter, output rose 2.1% from the prior quarter and was up 3.1% year-to-date compared with last year. This slow and steady growth is expected to continue until this summer. Production is expected to rebound after a year and a half of sluggish growth, pushing production up 6% this year. The impetus for this upturn will be increasing U.S. exports, due to the decline in the value of the dollar, inventory replenishment and growth in business equipment investment.

The Cahners Early Warning Indicator (CEWI) has been adjusted by deleting the unusual effects of recent changes in financial markets. The adjusted indicator points to an upturn in the economic business cycle with the next business peak in August of 1988. The CEWI is a weighted average of housing starts, the Dow Jones Industrial Stock Index and the money supply (M2), deflated by the Consumer Price Index. The CEWI has proven to be an excellent tool in forecasting the turning points in the economic business cycles about 12 months in advance. The black curve is a plot of the 12-month rate of change Index of Industrial Production. That change over a 12-month period can be determined by comparison with the line at 100. For example, the 106 level forecasts using the CEWI for the end of this year indicates that the average for all of 1988 should be 6% above 1987.

More information can be obtained from Elizabeth Baatz, economist, Cahners Economics Department, 275 Washington St. Newton, Mass. 02158.

Industrial production

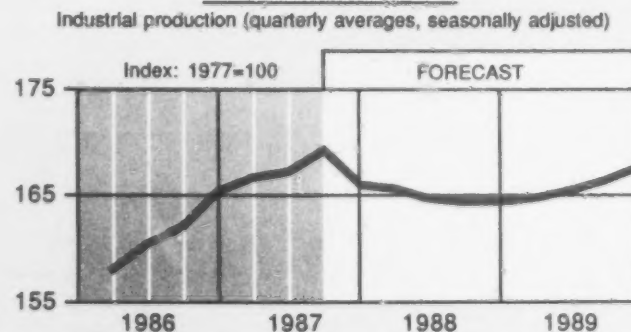
Defense and space equipment



Defense budget tightens

A softening in defense production was already evident by the end of 1987. Output grew about 4% in 1987 and will slow down to 1% growth in 1988. National defense purchases grew about 9% in 1987, down from 12% in 1986 and 15% in 1985. The silver lining in the slow growth scenario is that the push to modernize the armed forces will keep the electronics portion of the defense budget growing.

Aircraft and parts



Aircraft production outlook darkens

The production outlook for aircraft, missiles and parts is in sharp contrast to the recovery in other electronics industry. In mid-1986, when most other electronics industries slumped, growth in the rate of aircraft production peaked. Output of aircraft rose just 4% in 1987, a disappointing performance after the soaring growth rates of the previous few years. Cahners Economics estimates aircraft production will drop 1.5% in 1988.

The new shell game



Where is this U.S. chip really made? Even the major American chip makers are subcontracting out more and more of their production

The fabless semiconductor company is not a new phenomenon. For years, Silicon Valley has witnessed a sprouting crop of companies that have shunned manufacturing. Fledgling firms like Altera Corp., Chips and Technologies Inc., Vitelic Corp. and Xilinx Inc. are but a few examples of U.S. chip start-ups that have concentrated on the design side of the business, leaving their manufacturing for others to do.

At first, these fabless start-ups were mocked. "Real semiconductor companies have fabs," sneered some in the industry [ELECTRONIC BUSINESS Aug. 15, 1987, p46]. But if imitation is the truest form of flattery, the start-ups now have reason to feel smug. Many major U.S. chip makers — Advanced Micro Devices Inc. (AMD), Intel Corp. and National Semiconductor Corp., chief among them — confess that they are now farming out more and more of their manufacturing. In fact, Intel will subcontract out between 20% to 30% of its total production this year, says David L. House, senior vice president.

Many in the industry see this trend continuing. However, few are foreboding the day when any of the major U.S. chip companies wind up as fabless operations. Still, the advantages of subcontracting are as appealing as they are compelling and no one seems to know just when this trend will peak.

Sending one's unfinished chips elsewhere to be assembled and packaged by another company has long been a widespread practice. Many assembly houses in Asia have flourished by doing the back-end manufacturing for their American customers. Roughly 25% of all U.S. chip assembly is done by approximately 30 subcontractors in South Korea, Hong Kong and the Philippines, according to Richard W. Martin, president of contract assembler Indy Electronics Inc. of Manteca, Calif.

In addition to assembly and pack-

aging, many major U.S. chip companies are now using subcontractors for front-end manufacturing as well. These subcontractors, typically called foundries, will do the silicon wafer processing for customers. The chip foundry business is already a \$600 million industry, according to Integrated Circuit Engineering Corp. (ICE), a market research firm located in Scottsdale, Ariz. San Jose-based Dataquest Inc. puts the figure even higher, at \$940 million for last year, rising 27% to \$1.2 billion this year.

A touchy topic

Many U.S. chip executives hesitate to talk about their subcontracting activities. By admitting that their products are being manufactured elsewhere, they risk the implication of being inefficient. Furthermore, chip subcontracting is a particularly touchy subject because the bulk of foundry work is being done outside of the United States. According to ICE's figures, foundries in Asia do 58% of the world's subcontract work.

Motorola Inc., headquartered in Schaumburg, Ill., subcontracts "absolutely none" of its wafer processing, insists Jack W. Browne Jr., manager

products. Browne concedes that Motorola does not "very little" of its assembly and packaging work. "Less than 5%," he says, strongly maintaining that "to really be competitive, you've got to supply it yourself."

Browne is challenged by some who contend that Motorola's usage of contract assemblers is much more involved. Independent sources argue that Browne's "less than 5%" figure is really at least twice that amount. In fact, a former employee states that Motorola sometimes subcontracts as much as 20% of its back-end manufacturing.

Kevin McGarity, a vice president of Texas Instruments Inc.'s semiconductor division, will not quote an exact figure for subcontracting at his company, but says it's a "relatively small percentage." McGarity acknowledges that "We use subcontracting as a supplement to our own manufacturing." Indeed, South Korea's Hyundai Electronics Industries Company Ltd. and Japan's NMB Semiconductor are both currently making memory chips for TI.

Similarly, South Korea's Samsung Electronics Company Ltd. and Japan's Mitsubishi Electric Corp. are manufacturing chips for Intel Corp. of Santa Clara. Says senior vice president House: "We've been increasing our subcontracting over the last two to three years. It used to be a few percentage points before and now it's over 10%." House expects the figure to rise to somewhere between 20% to 30% by the end of this year and possibly higher in the future. "We might not stop at 30% but our objective is not to go to 100%," he says.

AMD has tighter reins limiting the company's subcontracting. "I would not see it growing, under any reasonable scenario, to more than 30%," says Gene Conner, a senior vice president of the Sunnyvale, California-based chip manufacturer. Currently, AMD subcontracts out less than 5% of its manufacturing. Conner expects this portion to rise to perhaps 25% within the next three to five years.

Even manufacturing powerhouse National Semiconductor engages in significant subcontracting activities. Raymond Farnham, vice president for advanced logic products, says that his company's use of subcontractors is also on the rise. The current figure at National Semiconductor is around 10%.

Some companies that have not yet jumped on the subcontracting band-

wagon may do so in the near future. Harris is currently doing all of its wafer fabrication in-house, according to Russell Morcom, vice president and general manager of semiconductor products. However, Morcom says, "We know that there are a lot of good sources out there for wafer fab." Consequently, he expects to start using foundries this year. He says that Harris will probably subcontract out a

Roughly 25% of all U.S. chip assembly is done by about 30 subcontractors in Korea, Hong Kong and the Philippines

Richard Martin of Indy Electronics

maximum of 5% to 10% of its wafer fabrication in addition to the 15% to 20% of assembly work that the company is already farming out.

Why the Koreans are happy

Several Korean semiconductor companies relish the opportunity to do foundry work. In fact, such work is often preferred over a licensing agreement, which is a mere transaction of money in exchange for the right to manufacture a certain product. In contrast, a foundry arrangement entails the customer company teaching the foundry company how to manufacture the contracted prod-

uct. "Foundry work is more desirable because it helps you to stabilize your manufacturing technology much more quickly," says Park Kwang Oh, a vice president in charge of semiconductor R&D for Hyundai.

Accordingly, Hyundai, a relative newcomer in the electronics business, entered into a host of foundry deals with experienced chip companies, TI chief among them. The work helped busy Hyundai's three new fabs, for which the company invested nearly a half a billion dollars.

But therein lies one danger in using foundries: the possibility that they may become competitors in the future. "You really have to ask yourself: Long-term, am I creating more monsters?" muses Intel's House. "It concerns me whether our foundries will remain happy in their role as just manufacturers or if one day we'll see them as across-the-board competitors."

TI executives may be asking themselves the same question about their foundry agreement with Hyundai. Clearly, the Korean behemoth is aching to become a world leader in the merchant semiconductor market. In the past, 80% of Hyundai's production was foundry work, according to Park. The figure has since fallen to 50% and Park says that it will continue falling in the future. He asserts that his company will one day break into the top 10 list of worldwide semiconductor companies.

The Japanese are also winners in the subcontracting game because of

Who makes what for the top five U.S. semiconductor makers

Company	Foundry	Products subcontracted
Texas Instruments	NMB Semiconductor Hyundai	Frame RAMs 256K DRAMs
Motorola	Toshiba	256K DRAMs*
National Semiconductor	NMB Semiconductor Hyundai	SRAMs
Intel	Mitsubishi Samsung	EPROMs DRAMs*
Advanced Micro Devices	Several Japanese companies	Not available

* Technically a supplier-reseller relationship

Source: ELECTRONIC BUSINESS

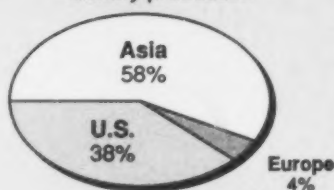
their shrewd bargaining practices. In exchange for manufacturing other companies' chips, many Japanese foundries have exacted technology rights from their U.S. customers [ELECTRONIC BUSINESS Feb. 15, 1986 p32]. Xilinx of San Jose had to divulge its innovative chip technology to Seiko Epson Corp. of Japan in order to get a manufacturing promise. In a similar agreement, WaferScale Integration Inc. of Fremont, Calif., disclosed its proprietary CMOS know-how to Sharp Corp. of Japan.

The Koreans and Japanese are not the only ones doing subcontract work. National Semiconductor's Farnham says that of his company's total production, approximately 10% is manufacturing done for other companies. Farnham sees the figure increasing in the future. Indeed, National is considering a reentry into the DRAM chip market by doing foundry work. And Intel received some of Altera's erasable programmable logic device technology in exchange for doing some foundry work for the Santa Clara, California-based start-up.

As with the back-end manufacturing business, where independent subcontract assembly companies like Indy Electronics have thrived, inde-

No prizes for guessing who rules the world's foundry business

Share of total 1987 foundry production



Total 1987 production
\$600 million

Source: Integrated Circuit Engineering Corp.

pendent foundries like the Taiwan Semiconductor Manufacturing Company Ltd. [ELECTRONIC BUSINESS Jan. 15, 1988] may also flourish. Established in 1986, TSMC is already seeing a huge demand for its foundry work. In fact, business has been so strong that the company is planning to invest \$220 million this year on an additional production facility to supplement its first fab, which cost more than \$100 million.

TSMC executives claim that they run the world's first major independ-

ent foundry. Independency has its advantages, claims Steve Pletcher, company vice president for marketing. According to him, "We know that we've had success this year because we don't compete against our customers. . . . We've actually had people come to use us because the foundry that they've had a longtime relationship with has now become a competitor and come out with products which are very, very similar to the products that they've been foundrying. The fact that we have no design engineering and no end products has been an asset."

Expecting to be cloned

Because of TSMC's success thus far, Pletcher says, "We expect to be cloned." In fact, Pletcher adds, "We hear rumors coming out of both the U.S. and Japan that there are people putting together business plans to clone us."

Critics, however, question whether TSMC's success is due to an industry trend favoring independent foundries. Gene Norett, in charge of semiconductor market research for Dataquest, credits TSMC's success instead with the company's seasoned management team of chairman Mor-

The pros and cons of subcontracting

Semiconductor industry executives cite two main reasons for the increasing popularity of subcontracting:

1. The semiconductor market by nature is cyclical and volatile. By using subcontractors, a chip company can quickly ramp up or ramp down its production to handle better the market's vagaries. Because of the increasingly high cost of semiconductor capital equipment — a single piece of lithography machinery currently tops \$1 million — companies are now finding that they *must* keep their fabs busy. "There's truth to the saying that a fab is like a pet dinosaur. If you don't keep feeding it, it'll eat you," quips Mark Reagan, analyst for Dataquest Inc. of San Jose.

2. Subcontracting provides for better leveraging of capital. Intel Corp. is farming out the production of its commodity-like memory chips in order to concentrate on making state-of-the-art microprocessors which command premium prices.

Using subcontractors also frees up one's R&D budget. "Subcontracting allows us to use our cash to get ahead instead of simply to harvest," says David L. House, Intel senior vice president.

In addition, foreign subcontractors often can manufacture a product at lower costs, a fact that most U.S. chip executives are loathe to admit. "It's tough competing against the labor rates in Southeast Asia," says Jack Beedle, president of In-Stat Inc. of Scottsdale, Ariz.

The benefits of subcontracting notwithstanding, few in the industry are predicting that the U.S. chip industry will ever end up fabless. "In order to be a major player in the worldwide semiconductor market, it is imperative that you must have a major manufacturing capability. . . . Anybody that does not have that commitment is susceptible to becoming a lesser player in the long run," insists Gene Conner, senior vice president of Advanced Micro Devices Inc. of Sunnyvale.

Many industry executives assert that the synergism between design and manufacturing is absolutely necessary. "If I have enough control over my manufacturing, then I can get 5% or 10% more out of the products I design. And even 5% in a head-to-head competitive challenge is a lot," says Jack W. Browne Jr., manager of the microprocessor products group for Motorola Inc., headquartered in Schaumburg, Ill.

Besides, subcontract arrangements do not always run smoothly. Vitelic Corp., a fabless start-up located in San Jose, is reportedly one year behind schedule because of a problem-plagued relationship with foundry Hyundai Electronics Industries Company Ltd. of South Korea. "In dealing with a company like Hyundai, it's not just a matter of transferring the technology and design over there; you also have to solve their manufacturing problems too. And that is why it's been so time consuming," says Alex Au, Vitelic president. □

Why I moved to California

Last January, Steve Pletcher uprooted his family and moved from Florida to Silicon Valley. Pletcher, marketing vice president for Taiwan Semiconductor Manufacturing Co. Ltd. (TSMC), made the transcontinental trek in order to relocate his company's U.S. operations from St. Petersburg to San Jose.

A year ago, Pletcher did not think he would now be living in California. At the time, Pletcher thought that much of TSMC's chip foundry business would come from captive semiconductor makers — companies such as computer manufacturers that make

chips for their own internal usage — and from other major chip consumers.

Little did Pletcher suspect that the vast majority of TSMC's sales would instead come from the merchant chip manufacturers, companies like Motorola Inc. and Texas Instruments Inc. "We always felt that the merchant semiconductor companies would probably be at least 50% of our business, but we never thought that it would be 95%," says Pletcher. Which is why TSMC moved its U.S. beachhead to Silicon Valley, heartland of America's merchant semiconductor industry. □

ris Chang — ex-TI vice president — and president James E. Dykes, former head of General Electric Co.'s semiconductor operations. "The jury's still out on how successful independent foundries will be," says Norrett. "People use foundries as a buffer and the acid test is: what will happen when the next chip downturn occurs?"

Indeed, that is the question that many industry executives are now asking themselves. It is easy to see why subcontracting would flourish in a market upswing when vendors are

scrambling to keep up with demand. But just how the foundry and contract assembly industry will hold up during the next chip recession is a subject for debate.

Nonetheless, U.S. chip industry executives now seem to have an altogether different attitude toward subcontractors than they had in the past. "Foundries and assembly houses have often been considered by management to be a safety valve: If I have to ramp up quickly, I will ramp up my subcontractors. When I have to ramp down quickly, I will ramp down

my subcontractors. We've seen that attitude *definitely* change," says TSMC's Pletcher.

Pletcher claims that companies like Intel, National Semiconductor and TI now view their subcontractors as key strategic partners. "I've talked to many of the top U.S. semiconductor manufacturers and all of them now have a definite foundry strategy which was unheard of a few years ago," says Pletcher. Accordingly, TSMC has negotiated long-term contracts, of three to five years, with all of its customers.

Certainly, the next chip recession will test the mettle of these new partnerships between chip companies and their subcontractors. Be that as it may, the alliances should survive because both parties appear strongly committed to each other. "If you cut your foundry off cold in a downturn, you can expect him to do the same to you in an upturn," says Intel's House. "You've got to have a plan where you keep your subcontractors active even during slowdowns." Consequently, House says that, with any foundry agreement, "We look for marriages, not affairs." Because of the strengthening relationships between chip companies and their subcontractors, Mark Reagan, Dataquest research analyst, asserts, "The foundry business is here to stay." □

Top semiconductor manufacturers

Estimated 1987 rank	1986 rank	Company	Worldwide semiconductor sales (\$ millions)	
			Estimated 1987	1986
1	1	NEC	\$3,240	\$2,560
2	2	Toshiba	\$2,980	\$2,270
3	3	Hitachi	\$2,560	\$2,160
4	4	Motorola ¹	\$2,380	\$1,960
5	5	Texas Instruments	\$2,050	\$1,800
6	10	National ²	\$1,725	\$1,525
7	6	Philips ³	\$1,550	\$1,325
8	7	Fujitsu	\$1,450	\$1,145
9	8	Matsushita	\$1,435	\$1,145
10	12	Intel	\$1,230	\$880

¹ Includes about \$150 million of nonsemiconductor sector packaging (nonhybrid)

² Includes Fairchild

³ Includes Signetics

Conversion rates:

1986: ¥170 = \$1

1987: ¥145 = \$1

Source: Integrated Circuit Engineering Corp.

TOP FOREIGN COMPANIES IN THE U.S.

The slumping dollar drags foreigners' sales with it

To deflect worse dollar wounds, overseas firms are freezing prices, cutting production costs and setting up U.S. plants

By Theresa Engstrom
and Linda Stallmann

This year, N.V. Philips GL replaced Matsushita Electric Industrial Co. as the foreign electronics company with the most business in the United States — but only by dint of its dogged defense against the common enemy — the falling dollar.

Foreign sales of electronic goods to the U.S. market reacted drastically to the dollar's continuing slide. The impact was evident from the trade figures: In 1985, when the dollar peaked at 260 yen, Japanese firms exported about 40% of their total production to the United States; the percentage is now about 33% and headed lower.

As a group, Japanese firms took the brunt of the attack. Matsushita's sales of goods to the United States were \$3.7 billion, virtually flat compared with last year's report. Mitsubishi Electric Corp., Nippon Electric, Sanyo Electric Company Ltd., Sharp, Sony Corp. and Toshiba Corp. — all listed among the top 10 firms — reported flat or lower sales to the United States.

The dollar has put pressure on Japanese firms to freeze prices, cut production costs through automation, and aim for higher-priced markets. Some companies are establishing plants in newly industrialized countries to cut costs, or in the United States to forestall angry political action.

Besides the political implication, the cheaper dollar has given foreign firms such as Matsushita an economic incentive to site a plant in the States. Real estate and construction costs are cheaper these days than at any time in the past several years,



The dollar has put pressure on foreign firms to freeze prices, cut production costs through automation, and aim for higher-priced markets

and moderate increases in U.S. labor costs over the past few years have removed much of the wage differential between the United States and Japan.

On the one hand, this favors U.S. producers. "The dollar's depreciation has given U.S. manufacturers an absolute competitive advantage over Japan," says Sara Johnson, senior economist at Data Resources Inc., Lexington, Mass., who expects a continuing, albeit moderate, decline in the dollar. However, Johnson points out that east Asian countries — including Korea, Taiwan, Singapore and Malaysia — whose currencies are tied to the dollar, enjoy a twofold advantage: a weak currency and truly cheap labor.

The sharpest companies have tried to anticipate such scenarios. N.V. Philips' sales increased 6% in the fiscal year ended December 1986, although that figure declined about 5 billion guilders when expressed in the Dutch currency because of the dollar's 26% depreciation against the guilder. "Needless to say, such a huge decline has a considerable adverse impact on both the competitiveness and the translation of the sales and income of the company, which is increasingly active in the United States and in dollar-linked regions," write sC.J. van der Klugt, president of Philips, in his report to shareholders.

Reducing parts counts

Philips' profit picture was improved somewhat by the sale of some subsidiaries. However, the company also brought on-line its optical media division; and color televisions, video recorders and compact disc players contributed to a 14% increase in its sales of consumer electronics prod-

Don Egan

Top foreign companies in the U.S.

Rank 1987	Rank 1986	Company	U.S. electronics sales (\$ millions)		1987-1986 total consolidated sales (\$ millions)	1987-1986 profit before taxes (\$ millions)	Fiscal year ended	Country of origin
			1987-1986	1986-1985				
1	2	Philips	\$3,993	\$3,430	\$25,131	\$894	12/86	Netherlands
2	1	Matsushita	3,700	3,700	28,067	2,706	11/86	Japan
3	3	Hitachi	3,030	2,920	33,210	1,769	3/87	Japan
4	4	Northern Telecom	2,860	2,876	4,384	441	12/86	Canada
5	5	Sony	2,634	2,250	8,180	472	10/86	Japan
6	6	Toshiba	2,000	1,500	22,655	534	3/87	Japan
7	7	NEC	1,948	1,450	16,779	398	3/87	Japan
8	8	Sharp	1,600	1,400	7,868	293	3/87	Japan
9	9	Siemens	1,500	1,340	23,261	1,518	9/86	West Germany
10	10	JVC	1,335	1,200	4,839	136	3/87	Japan
11	13	Mitsubishi	1,200	1,000	14,435	261	3/87	Japan
12	11	Sanyo	1,200	1,200	7,246	77	11/86	Japan
13	16	Fujitsu	1,170	650	12,256	329	3/87	Japan
14	12	Canon	1,150	1,090	5,523	172	12/86	Japan
15	14	GEC	1,100	980	8,395	1,069	3/87	Britain
16	28	CGE	865	320	12,589	423	12/86	France
17	17	Olivetti	835	620	5,452	537	12/86	Italy
18	18	Samsung Electronics	800	550	16,967	256	12/86	Korea
19	21	Kyocera	542	465	1,892	259	3/87	Japan
20	19	C. Itoh	500	500	101,112	152	3/87	Japan
21	20	Racal	475	470	2,065	160	3/87	Britain
22	26	Pioneer Electronic	470	390	2,253	91	9/86	Japan
23	24	Oki Electric	460	400	2,791	28	3/87	Japan
24	15	Schlumberger	450	900	4,938	-1,760	12/85	Netherlands
25	22	TDK	450	430	2,367	222	11/86	Japan
26	25	Lex Services	442	390	1,623	39	12/86	Britain
27	23	Thorn EMI	430	430	5,096	255	3/87	Britain
28	30	Thomson-CSF	425	300	5,610	422	12/86	France
29	29	Ericsson	400	310	4,671	134	12/86	Sweden
30	47	Bayer	370	NA	21,141	1,712	12/86	West Germany
31	32	Alps	325	240	2,532	98	3/87	Japan
32	31	Plessey	280	260	2,288	295	3/87	Britain
33	27	Commodore	230	360	807	32	6/87	Bahamas
34	33	Brother Industries	185	138	1,034	60	11/86	Japan
35	48	Bosch	180	NA	11,268	782	12/86	West Germany
36	39	AEG	140	100	5,821	NA	12/86	West Germany
37	34	Mitel	139	130	326	-1	3/87	Canada
38	35	Nixdorf	130	130	2,336	364	12/86	West Germany
39	38	Mannesmann	120	110	8,941	268	12/85	West Germany
40	37	Canadian Marconi	98	110	164	28	3/87	Canada

U.S. electronics sales are ELECTRONIC BUSINESS' estimates. All figures are converted at the exchange rates at the end of the fiscal years, thus a variety of accounting and exchange rates are represented.

Source: ELECTRONIC BUSINESS

The decline of the U.S. dollar versus...



ucts. In its consumer electronics line, Philips is striving to "reduce the part count," says a spokesman — thus reducing the cost of production.

Matsushita had some good news, some bad. The yen's strength meant that overseas sales of the company's products fell 20% in 1986 to about 44% of the total. But the company added several new American production facilities to its existing string, including a video tape recorder plant in Washington state and a facility for making car stereos in Georgia. Despite lower capital investment, Matsushita increased its investment in research and development 4%, to about \$1.5 billion, which is 5.5% of sales. "Day to day efforts" are being made to reduce operating costs, says Ken Shimba, public relations manager of Matsushita Electric Corp. of America.

Another tactic is to aim for more profits per product. Matsushita is moving toward more products with higher value-added in order to avoid competing in the war-torn low end of the market, says Shimba. For example, he says, Matsushita's Panasonic division is pushing a more expensive video cassette recorder with a scanner that will read bar codes printed in a special directory of viewing schedules. The company hopes that eventually *TV Guide* magazine will include bar codes.

Northern Telecom Ltd., based in Canada, had a happier story to tell.

Chairman Edmund B. Fitzgerald reported a 5% increase in earnings, the result of a strong second half that offset a 23% decline in the first six months of 1986. The company focused on improving manufacturing, marketing and research, especially for the "extremely competitive North American business communication systems market," where it sells 95% of its product.

Sony hit hard

Sony, conceding it was hit hard by a difficult United States sales climate as well as by the yen, decided in early January to raise prices on many of its electronic products, following in the footsteps of Matsushita. With overseas sales accounting for more than 70% of sales, Sony had reported a 7% drop in sales, and an 11% drop in overseas sales for fiscal year 1986. This was particularly hard to take considering the company's performance in the U.S. market; when measured in local currencies, Sony's U.S. sales grew 24%. However, deteriorating profits resulted in a 75% decrease in operating income, mostly from poor export profits, according to Sony chairman Akio Morita. One defense tactic adapted by Sony was the redesign of many of its products to include fewer parts, as well as automating production facilities, and streamlining distribution channels.

Toshiba's 43% decline in net income was blamed partly on 100% tar-

iffs on personal computers, color televisions, and electric tools imported from Japan. To counter the trade barriers, the company began producing more of its products locally, and increased its shipments of value-added devices such as application-specific integrated circuits.

The firm also formed strategic alliances with companies that have footholds in their native markets: A trilateral program with the United States' General Electric Co. and Germany's Siemens AG, for instance, has been formed to develop standard-cell libraries for application-specific ICs. A separate agreement with Motorola Inc. will result in jointly produced advanced microprocessors and memories for the Japanese market.

With such alliances becoming more common, analysts agree that political action in the United States counts for little, compared with the ingenuity of firms that truly have an international mindset. "Any trade bill produced by Congress is expected to be vetoed by the president," says DRI's Johnson. However, she adds that trade bills make little difference in today's climate. Offshore production facilities; diverse and flexible sourcing patterns; automation of design and production facilities; cooperative agreements with trading partners of different nations: all have transformed the face of world trade to one that is neither American nor Japanese, but distinctly multinational. □

PASSIVE COMPONENTS

Sudden switch: Fast chips need speedy interconnects

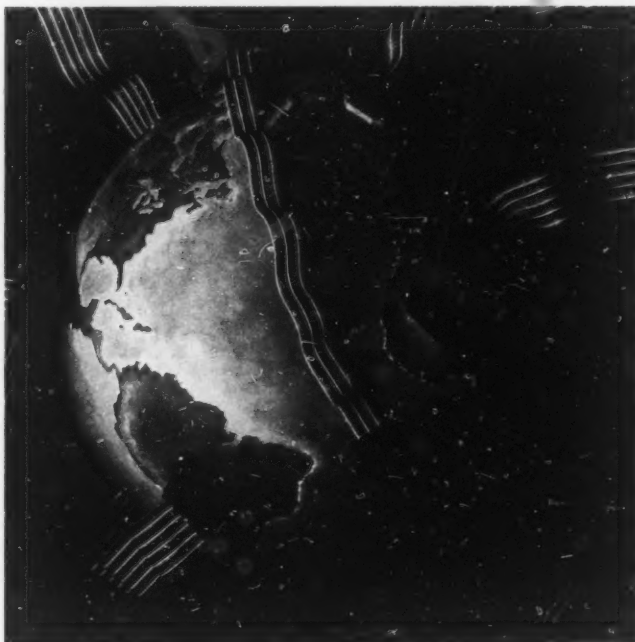
New materials, multichip modules and surface mount technology keep signals flowing swiftly between chips

By Michael R. Leibowitz

Smaller, denser, faster. Those three words sum up the forces driving equipment makers to change the ways they assemble electronic components into electronic systems. A whole new range of interconnect technologies has arrived to satisfy customers' overwhelming preference for the smallest products, the fastest products and the ones that are most laden with features.

Thank the increasing density and speed of integrated circuits (ICs) for the changes rippling through the interconnect area. As chip makers routinely pack hundreds of thousands of devices on an integrated circuit, faster technologies and materials are forcing signals to switch as quickly as a nanosecond or less. The new approaches to interconnect pursue a single goal: take most advantage of the chips' benefits when you tie them together. Do not dampen switching speeds; do not add unnecessary nanoseconds of interconnect delay; and squeeze out the excess space from around the components.

Of all the new interconnect trends, surface mount technology (SMT) is the most important. For years, the technology that offers a threefold increase in density by mounting components on the surface of boards instead of through-holes had idled, remaining the primary domain of a



New approaches to interconnect pursue a single goal: take most advantage of the chips' benefits when you tie them together

small number of large systems makers and contract manufacturers. In the past year, however, SMT has made great strides in the United States toward becoming a mainstream interconnect technology.

In 1987, SMT production machinery makers witnessed a 15% to 20%

growth in demand over the previous year, according to Pamela J. Gordon, president of Technology Forecasters, a Berkeley, Calif., market research firm. And the value of circuit boards produced with SMT in the United States last year surged to \$18.5 billion, or 12% of total board production, up from 9% in 1986. Gordon expects this number to climb to 39% by 1992.

SMT growth was impeded until recently by a number of factors: a scarcity of surface-mountable components, nonexistent standards and lack of experience by users. According to Charles-Henri Mangin of Ceeris International, an electronic assembly consultant based in Old Lyme, Conn.,

manufacturers have been reluctant to invest in SMT production lines, which often cost in excess of \$1 million. "That's a big investment," he says, "especially considering the amount of brand new through-hole equipment [already] on the factory floor."

Much of this is changing. Users report an improved variety of SMT components, lower costs, and better manufacturing yields as they gain experience with the intricate SMT process. Although in many cases, SMT-produced boards still cost somewhat more than their through-hole counterparts, the gap is narrowing, and some users have either matched their through-hole costs with SMT or ex-

pect to do so soon.

But, according to experts, one very important factor boosting the acceptance of surface mount in this country is the need for the United States to remain competitive with overseas equipment makers, many of which have already adopted SMT. Small size and increased functionality — for the competitive edge, U.S. producers realize. Besides its basic density advantages, SMT allows product designers to use the latest generation of very dense, high pin-count ICs, which are packaged in packages having only .025-inch center spacing between leads.

James Mitchell, president of Quad Systems Corp., a Horsham Pa., maker of SMT pick-and-place machines, points out that acceptance of SMT by the Japanese has reached 70% to 75%, up from 50% a year ago and 35% two years ago. "They were taking out through-hole lines and replacing them with surface mount lines," he says.

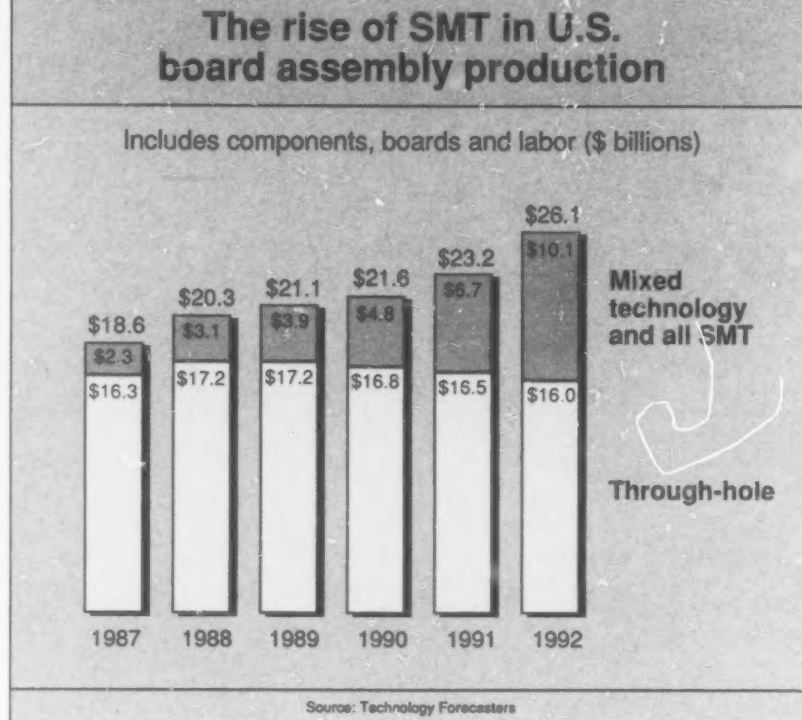
But U.S. equipment makers are also making the transition. James Elliott, director of advanced manufacturing for Western Digital Corp., says that by July, his company will have spent \$35 million on five SMT facilities capable of producing 10 million SMT boards per year. At that point, over 85% of Western Digital's board production, which includes disk controller cards and add-ins for IBM personal computers, will be in SMT.

Industry observers say more and more U.S. electronic equipment makers are following suit. Gordon says 900 companies possess SMT capability already, with many more using SMT through contract manufacturers. She expects 200 to 250 more to achieve SMT capability in 1988. Says Ceeris Mangin: "Since the competition has it and the market wants it, we don't care about the cost. That's not the issue."

Impedance-matched circuits

Exotic materials and components are becoming mainstream interconnection tools as equipment makers boost system clock rates into the hundreds of megahertz and beyond.

The reason is physics. Conventional circuit board materials, cabling and connectors provide a "transparent" interconnection for slow- to medium-speed signals. These interconnections, however, can appear to fast signals as a bottleneck that reduces speed, or worse, as an obstruction that can cause the circuit to malfunction.



tion. And high-speed circuit makers find conventional PCB materials foil much of their circuit cleverness by delaying the propagation of signals, degrading the rise times of signals and causing signals to cross between adjacent PCB traces.

The first solution, for many equipment makers, is to replace conventional interconnect materials with impedance-controlled products, such as precision PCBs, flexible circuits and

PTFE gives PCBs a very low dielectric constant, a quality which makes signals travel faster and experience less loss

impedance-controlled connectors.

And sales of these products are booming, according to Philip Lapin, with Electronic Market Consultants of Redwood City, Calif. Lapin estimates that precision, impedance-controlled PCBs for the U.S. computer industry tallied \$300 million to \$400 million in sales during 1987, or 20% to 25% of the total computer PCB market. He expects this figure to grow as much as 14% per year over the next several years.

The impedance-controlled interconnect market features competitors such as Rogers Corp. of Rogers, Conn. and E.I. du Pont de Nemours

& Co. of Wilmington, Del., which manufacture precision PCB laminates for fabricating multilayer PCBs that maintain tight tolerances on laminate thickness and dielectric constant — key factors that influence PCB impedance. These companies also manufacture flexible circuits and connectors for maintaining a constant impedance when routing signals between boards.

The next step in high-speed interconnect — for particularly fast circuits — is to shift to expensive PCBs made with polytetrafluoroethylene (PTFE), the generic name for DuPont's Teflon frying pan coating. PTFE gives PCBs a very low dielectric constant, a quality which makes signals travel faster and experience less loss: traces can be placed closer and not be subject to "crosstalk." Key players in the PTFE market include Rogers, W.L. Gore and Associates Inc., of Newark, Del., and Keene Corp. of East Providence, R.I.

Analyst Lapin pegs the 1987 value of PTFE-based PCBs at \$120 million and expects it to grow 15.5% over the next several years. Military applications, such as radar and missile systems, represent 65% of the PTFE business, with telecommunications following at 20%. But computer applications, at 5% of the PTFE market, comprise the fastest growing segment, expanding 21% a year.

Rogers Lockard sees a great potential demand for his company's new RO2800 low-dielectric laminate

MARKETS

among performance-oriented mini, mainframe and supercomputer makers. "The large computer companies, who have never bought Teflon boards before, are considering them for future systems," says Lockard.

However, equipment makers pay a premium to build boards of this material: RO2800 runs roughly 10 times the cost of standard glass-epoxy material, says Lockard. Still, "our business is growing very rapidly," he reports. Although no customers are yet using this material in production, Lockard expects the evaluation purchases from computer makers to turn into production-level buys between late 1988 and 1990.

For high-performance computer makers, the only way to speed the circuit up is by reducing the interconnection distance between ICs. For them, and for a small number of mostly military contractors for whom space is priceless, a new technology has emerged that is expected to gain popularity in the coming years. The multichip module is expensive, but for those who need the ultimate in performance or density, experts say it is the closest thing to having the entire system condensed onto a single silicon wafer.

Multichip modules are either pieces of ceramic or wafers of silicon on which the interconnecting traces are etched, by what is essentially a semiconductor fabrication process. After the module is fabricated, ICs are attached and bonded and the ensemble is tested. The result is functionally equivalent to a populated printed circuit board — but much faster and a dazzling one-sixth of the size.

Jack Balde, president of Interconnection Decision Consulting, a Flemington, N.J., packaging consultant, says there is great interest in multichip modules among performance-oriented computer makers and the military. "There is a tremendous amount of action taking place behind the scenes," says Balde. "Not many articles appearing, but it's going to be the explosive area."

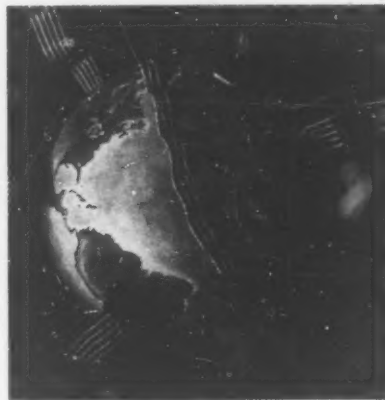
And BPA Ltd., the market researcher, projects that worldwide consumption of multichip modules will mushroom from \$50 million last year to \$400 million in 1990.

Experts say that part of the new multichip activity is spurred by rumors that the Japanese are investing heavily to put them in computer equipment. "Our customers are scared to death that they'll be beaten

out by the Japanese," says Clyde Lofdahl, business manager of Raychem Inc.'s multimodule operation.

Many systems makers are mum about their work with multichip modules — much of it now in development stages. But according to Lofdahl, 85% of their customers for multichip modules are interested in speed and are trying to build systems having clock rates from 40 megahertz to a gigahertz or more. The other portion consists mainly of military equipment makers interested in ultrahigh density.

Raychem, which only began mul-



Experts say multichip modules are the closest thing to having the entire system condensed onto a single silicon wafer

tichip module production in July 1987, is one of the first independent companies to produce multichip modules for customers under contract; virtually all prior multichip module work has been by captive makers such as AT&T, Digital Equipment Corp. and IBM.

Raychem fabricates a 5-inch-diameter, circular substrate which can be cut to produce modules of various sizes, accommodating from two to 50 individual chips. Actually, the number of chips interconnected on a multichip module depends on "the courage of the customer," says Lofdahl, since traces are too small to probe, repair can become an almost impossible task on modules sporting many ICs.

So far, Raychem provides only unpopulated modules to customers.

Customers are responsible for bonding the die to its pads, attaching a connector and testing and repairing the completed assembly.

Some customers would like to hand over the assembly process to the module maker, but this raises the issue of security, since the module can represent a major portion of the product. Lofdahl says assembling the module requires access to a customer's test vectors, comprehensive directions for testing the system, and the most zealously guarded of proprietary information. "It's like asking for their wife for the weekend," he says.

High fabrication cost is another problem of multichip modules. The design and tooling cost for a 5-inch wafer can run between \$70,000 and \$145,000. Production costs can range from \$75 each for low-complexity 1-inch-square modules to between \$1,000 and \$4,000 for 9-inch-square modules, with price varying according to complexity.

With prices like this, multichip modules are not for everybody. "We're a rifle-shot package concept," admits Lofdahl. "But," he adds, "the customers that need us, need us badly."

New IC packages

For equipment makers who cannot afford to deal with multichip modules, some good news: IC makers, equipment makers and packaging houses are helping with the interconnect problem by supporting a range of new packages to replace the bulky, old dual in-line package (DIP) that has endured in the industry since the 1960s. In fact, the new packages will continue eroding the DIP's 82% share of the 43 billion unit IC package market to 51% in 1992, according to Integrated Circuit Engineering, a Scottsdale, Ariz., market researcher.

These new packages are smaller, lighter and feature up to several hundred pins to meet the high input/output (I/O) requirements of such chips as application-specific ICs. They boast electrical characteristics superior to those of DIPs and possess a greater ability to dissipate the watts of heat that such chips generate. Lead-spacing can be as tight as one-quarter that of the DIP (.025-inch versus .100-inch). Surface-mounted "J" or "gull-wing" leads are gaining popularity at the expense of conventional through-hole pins.

Despite the boggling assortment of new packages, experts report some consensus is developing around sev-

MARKETS

eral newly popular packages.

The biggest trend in packaging, according to experts, is the wholesale move by the industry to packaging high-volume commodity ICs in small outline ICs (SOICs). "This is by far, the highest growth package in the world," says Daniel Rose of Rose Associates, a Palo Alto, Calif., packaging consultant. In the United States alone, says Rose, SOIC usage grew from a monthly volume of 10 million at the beginning of 1987 to 100 million by December 1987. The reason, says Rose: "All the little transistor-transistor logic circuits that used to be packaged in 14-lead DIPs are being packaged in 14-lead SOICs."

The SOIC provides a 60% space savings over the DIP, and weighs less, points out Dean Winkleman, a researcher with Integrated Circuit Engineering (ICE). Consequently, the SOIC has become the package of choice for surface mounting "jelly-bean" ICs having eight to 20 pins, such as dynamic random access memories (DRAMs), logic circuits, and linear ICs. Winkleman says that SOICs currently hold 6% of the worldwide IC marketplace, up from practically zero in 1980. The growth derives mainly from applications in the United States and Japan. Winkleman says the growth march of the SOIC has only begun: he anticipates SOICs will capture 25% of the market in 1992.

Look for the zigzag in-line package (ZIP) to continue gaining popularity for packaging DRAMs, as users that are staying with through-hole mount technology choose it as a high-density alternative to DIPs. "You can actually achieve superior density over the SOIC if you have the vertical clearance," says Winkleman. He sees ZIPs garnering 20% of the worldwide memory market by 1992, with SOICs and DIPs each taking 40%. Today, the ZIP's share of the memory market is "less than 5%," says Winkleman.

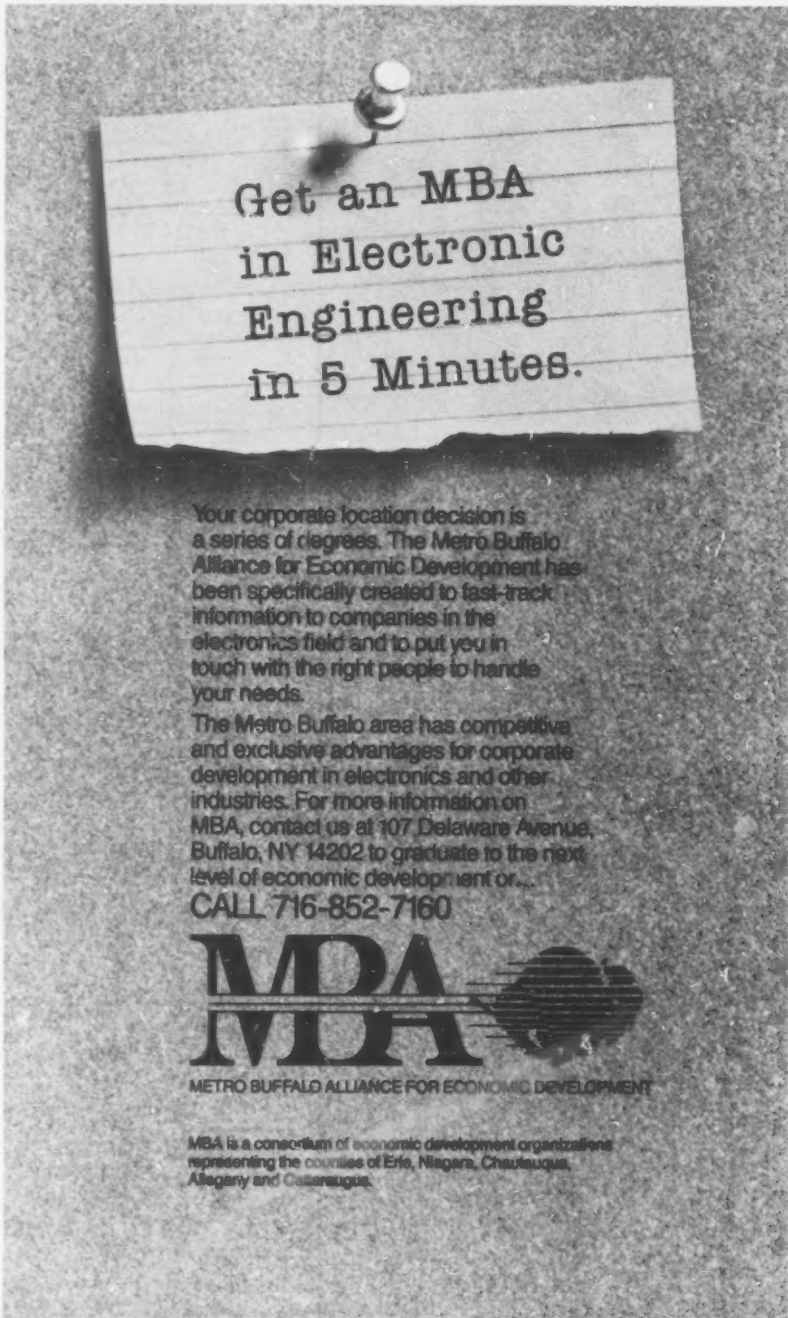
The plastic quad flat package (PQFP), employing small, molded bumpers on each of its four corners, will also see healthy growth for ASICs and standard very large-scale integrated chips. The bumpers protect its 40 to 244, .025-inch-spaced gull-wing leads from becoming tweaked during handling. And many in the industry see the package as the lower profile, higher density version of the plastic leaded chip carrier (PLCC). Winkleman estimates that the .050-inch lead-spaced PLCC will hold steady at roughly 3% of total IC package usage,

while the PQFP will leap from 1% currently to 5% by 1992.

Pin grid arrays (PGAs) will remain the preserve of high-I/O chips, 100 pins and up, and high-power VLSI circuits that need the heat-dissipating capabilities of ceramic. ICE estimates that PGAs will grow from slightly under 1% of the market today to 2% by 1992.

Other package developments to watch: leaded ceramic chip carriers,

whose leads absorb the thermal expansion that causes cracking on leadless ceramic chip carriers. ICE expects these to grow to 1% of IC units by 1992; also, premolded plastic packages utilizing a corrosion resistant silicon gel, as a less expensive replacement for hermetic ceramic packages. The Institute of Electrical and Electronics Engineers is now evaluating gels and military qualification could start later this year. ☐



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SEMICONDUCTOR PRODUCTION

VLSI lithography: Thin lines, thinner profits

Making the hardware that writes circuit patterns on wafers is becoming increasingly costly and complex

By Carol Suby

Microolithography — the process by which integrated circuitry is patterned onto semiconductor wafers — presents myriad challenges for the makers of the equipment that aligns the circuit pattern masks with the wafers. Leading-edge VLSI chips, such as 4-megabit dynamic RAMs, are packed so densely that they call for design rules — the smallest element of a transistor that can be fabricated — smaller than a micron. In addition, these chips require 10 or more patterns to be drawn atop one another with overlay accuracies of 0.3 micron or better. This task is comparable to placing a human hair on a football field with an accuracy that is the equivalent of getting a hole-in-one from an 18-mile drive.

Creating a piece of such precision hardware can cost tens of millions of

dollars and typically requires a two-year development time. Once that is achieved, vendors are faced with a myriad of external issues. Masks or reticles — master images of circuitry used in the process — must be up to snuff to handle the ever-shrinking linewidths. And special resists — the photosensitive chemicals used to coat the wafers and receive the masks' images — are also required to handle submicron technology.

THE TECHNOLOGY

Beyond equipment and material issues, competition is fierce, profits run from thin to nonexistent, and the equipment manufacturers are buffeted by the cyclical market for semiconductors.

The number of transistors integrated into a chip has moved to the very large-scale integration level. Fea-

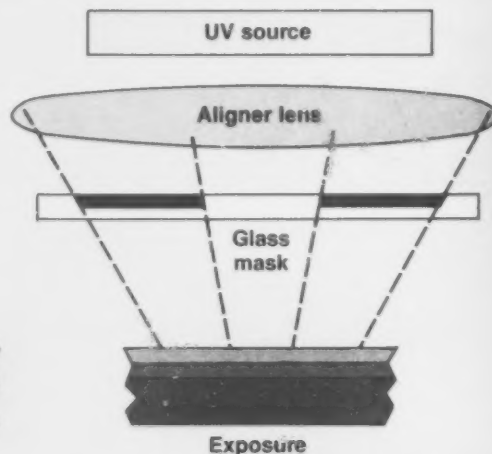
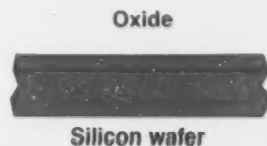
ture sizes are moving toward smaller than 1 micron (a millionth of a meter). In addition, VLSI chips must be made by successive alignment and fabrication of 10 or more patterns for the circuit elements and their interconnections. Consequently, microolithography, the process of laying down the images for those elements, has become increasingly complex.

There are two basic categories of equipment used to perform this task: alignment systems and direct-write systems. Within the alignment category, optical or photolithography equipment is most commonly used today. This process works very much like making prints from camera film, whereby a lens focuses light through a negative, exposing and transferring an image to a photosensitive coating on the print paper.

In VLSI photolithography, a computer-generated circuit pattern is first

Microlithography

The objective of microlithography is to open small windows into the wafer's protective oxide, through which the silicon is doped to transform transistors. A silicon wafer, protected with oxide or nitride, is coated with positive photoresist and placed in the aligner for exposure to the mask image. . .

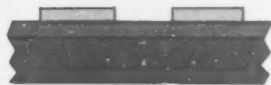


produced on a master image — a reticle or mask. Its quality and the image definition are critical, because any blemishes or imperfections will be transferred from the mask to the wafer. For VLSI masks, images are drawn on a glass plate by an E-beam.

This master image is positioned over a silicon wafer that has been coated with photoresist, a photosensitive diazo chemical. Then, light or ultraviolet rays pass through the clear areas of the mask and expose the photoresist on the wafer, forming a latent image. Whenever possible, the image for the whole wafer is transferred in one step. The more critical alignments and finer circuit features, however, must be transferred in successive steps by a stepper aligner that indexes the mask over the wafer, imaging a few circuit cells at a time. The resist areas so exposed polymerize and harden, whereas the rest of the resist can be easily removed chemically or with plasma. This permits selective doping of the wafer, by diffusion or ion implantation, to build the desired circuit properties into the silicon.

Only a few years ago, a design rule of 1 micron was considered the limit for optical lithography. Today, however, the combination of lenses that are efficient in the ultraviolet range down to 0.365 micron (called i-line), and high-purity photoresists, has allowed manufacturers of stepper aligners to push beyond that barrier. "It sounds unbelievable. They are pushing the limits of light optics," says Dr. Hans Friedrich, head of the "Megaproject" at Siemens AG. This project, partially funded by the West German government, has a goal:

... after resist development and removal, the oxide is etched to open a window. "Design rule" is the smallest window that can be opened. Projection mask aligners expose the whole wafer at once. Aligner steppers, which are used to resolve finer features, image only a few cells at a time and must repeat the pattern by stepping across the wafer. The larger the aligner lens' reduction, the finer the features it can resolve, but the longer it takes to step across the wafer.



Etched resist



Etched oxide

catching up with Japan in 4Mb DRAMs.

"Our design rules for the 4Mb DRAMs are, conservatively, 0.7 micron," says Friedrich, "but we can go to 0.6 using optical lithography." He thinks even 16Mb DRAMs can be built with 0.5 micron rules. Beyond that, however, photolithography hits the physical barriers imposed by the diffraction of light as it passes through the small openings of VLSI masks. To draw finer lines, lithography needs beams narrower than UV sources can provide. Companies worldwide, some with their governments' help, have invested heavily in lithography using the next narrower source of radiation: X-rays. Another approach altogether eliminates the masks; it consists of writing the IC patterns directly onto the wafers.

Today, X-ray lithography equipment remains in the experimental stages of development and is expected to continue there for some time because many factors remain to be solved with this technology. Current commercial resists do not work well with X-ray because their variations in thickness are often greater than the linewidths the X-ray is drawing. An even bigger problem is developing a mask or reticles that remain stable under a barrage of X-rays.

Direct-exposure systems, which write IC patterns directly on the wafer, also remain primarily in an experimental stage. This category includes three major product types — electron- or E-beam, focused ion-beam and laser direct-write equipment. E-beam systems are the only ones to reach commercial use; primarily for prototyping and for small

lots, up to 10,000 ICs.

E-beam systems have become the standard equipment for making photolithographic masks. However, an emerging technology — laser scanning — is inching its way into mask making.

THE MARKET

Within the microlithography and mask making market, wafer exposure equipment has the lion's share of revenue. Last year, worldwide sales of wafer exposure equipment totaled \$697 million, or 75% of the total \$934 million market. That share is expected to hold into the future, according to research firm VLSI Research Inc., in San Jose. But the market is not large enough "to support all of the competition," says Aubrey "Bill" Tobey, president of consulting firm ACT International Inc., in Burlington, Mass.

During the recent downturn, the roster of microlithography equipment vendors began to shrink. Some of the heavy hitter dropouts include: Eaton Corp., which exited the wafer stepper arena; and Varian Associates Inc., which folded its direct-write E-beam operations.

Those remaining in the game are pushing to keep abreast with leading-edge technology. "All equipment people are struggling like hell to get to submicron technology. But the fact is, the manufacturers are at 1 micron," says Richard Ruddell, president of consulting firm Ruddell & Associates Inc., in Redding, Calif. People are "stalling" at 1 micron, he adds. In fact, according to estimates by VLSI Research, of the 3.5 billion ICs produced in 1990, 1.4 billion, or 40% of them, will be in the 1.6-micron to 3.0-micron range. Only 316 million, or 9%, will fall into the 1.5-micron and below category.

Consequently, some companies claim that over the next several years most battles in this marketplace will be fought along nontechnological lines. Many customers agree. At AMD Inc., the greatest concern regarding production equipment is its productivity, says William Arnold, manager of VLSI lithography development at the company's headquarters in Sunnyvale, Calif. And low productivity has been the biggest disappointment regarding wafer steppers, he adds. Currently, Arnold would like to double the net wafers per hour that he's getting.

Other concerns that Arnold points

to — set up times, yields, calibration or machine stability, the ability to make adjustments “on the fly” — are the very platforms upon which competitors are trying to separate themselves.

Indeed, today's customer wants a great deal more than fine-line resolution, says Peter Simone, president and chief operating officer at GCA Corp., in Andover, Mass. Custom and semi-custom houses, which might run only 20 to 100 wafers per work order, are taking the lead in demanding better overall performance in the lithography equipment they buy, Simone adds. “There's more focus on equipment utilization, higher throughputs on smaller lots and demand that equipment be as close to self calibrating as possible,” he says.

While both sides of the vendor/customer fence repeat the same litany, both also admit that, at least in the United States, their relationships have a long way to go toward improvement. “A fundamental problem is that there's no real honest communication between device manufacturers and equipment manufacturers,” says Ruddell.

In fact, time and again, manufacturers have built equipment according to customer demands only to find that when the product was ready for market, the customers — for a variety of reasons — were no longer interested. In defense of the customer, AMD's Arnold points out that, while it's tough to predict what will be needed three or more years out, the rapid changes in equipment offerings are also frustrating for buyers. In wafer steppers alone, with seven different competitors averaging 18-month cycle times for product introductions, Arnold says, about every three months buyers are faced with yet another product announcement. “But you have to learn how to live with that,” he sums up.

In addition to keeping a close eye on developments in wafer steppers, chip makers must also keep abreast of two other technologies in the wafer exposure equipment market: X-ray lithography and E-beam. VLSI Research expects that by 1991, worldwide sales of X-ray lithography systems will total \$52 million, or 4% of the total wafer exposure equipment market. For E-beam wafer exposure equipment, the forecast is \$205 million, or 15% of that market in 1991.

Within the industry, bets on X-ray technology are split down the middle. Some observers believe X-ray will



AMD's WILLIAM ARNOLD: The greatest concern regarding production equipment is its productivity

take over once optical systems can no longer do the job. Others say X-ray has missed its window of opportunity and will never become commercially viable.

Many X-ray nay-sayers are betting that direct-exposure systems will replace optical-based systems. Most direct-exposure systems today are still

During the recent downturn, the roster of microlithography equipment vendors began to shrink

experimental. Of three approaches in contention — using either electron beams, ion beams or lasers — E-beam systems are the most commercially successful.

THE COMPETITION

If history repeats itself, Nikon — the current leader in worldwide unit shipments of wafer steppers — could be in for an upset. Since the 1960s, when Kulicke & Soffa Industries Inc.'s contact aligner became the industry standard for lithography, “no company has ever dominated the lithography market for more than five years,” says G. Daniel Hutcheson, of VLSI Research.

Just in the past 10 years, three new leaders have emerged, and industry watchers are already placing their

bets on the fourth. Optics specialist Perkin-Elmer Corp. of Norwalk, Conn., became the leader in the 1970s with its projection mask aligners. “By 1981, the game shifted from projection systems to steppers. Perkin-Elmer was on the defensive,” says Hutcheson. And, GCA was the beneficiary. This company accounted for 73% of the 240 wafer stepper machines installed during 1981, according to Ruddell of Ruddell & Associates. GCA's days in the sun, however, were short-lived.

By 1985, Nikon Precision Inc. had become the clear leader in wafer steppers. This subsidiary of Japan's Nippon Kogaku KK had installed only 25 wafer steppers during 1981, compared to GCA's 175 installed that same year. Four years later, the tally was Nikon: 145, and GCA: 115, according to Ruddell.

A winning factor was that Nikon's was “a production worthy system,” suggests Gil Varnell, senior vice president of technology and R&D for Nikon's U.S. headquarters in San Bruno, Calif. It was also “the first to offer guaranteed uptime specs,” and strove to beat the competition in service, Varnell adds.

“Some mistakes were made,” concurs Simone of GCA. “We had to do more work on application support — helping a customer apply the system to his process. . . . We also had to address performance issues, and we were late in getting a solid 1-micron machine to market.” Today, GCA is struggling to turn its fortunes around. The management has been revamped and, according to several industry analysts, the company has righted its equipment shortcomings. Also, a \$20 million financing deal, inked at the end of 1987, will allow the company to ramp up production to meet backlog demands, which totaled \$41 million at the end of last year's third quarter.

Meanwhile, Nikon has little time to rest on its laurels. Nikon's dependable equipment and fastidious attention to support might have put them on the top of the heap, but it won't necessarily keep them there, according to consultant Tobey of ACT International. “When you have competition, you have to step on their throats. You've got to kill them,” advises the former GCA executive. “Canon has decided it's going to take the market. Nikon and Canon will get into some battles, but Canon will win. It's the bigger animal.”

Others in the industry are also

looking to Canon as the next winner, but there's still room for a surprise. Although Canon might be the "best bet," for the next market leader, many other players are still in the running, suggests Hutcheson. The number of unit sales for Ultratech Stepper of Santa Clara, Calif., a unit of General Signal Corp., "has grown by almost five times in the last year... while Canon has roughly doubled and Nikon is up around 35%," according to Hutcheson. But, he adds, dark horse GCA "could make a comeback, and you never know what Nikon's got in R&D." Another company to watch, Hutcheson notes, is Tempe, Arizona-based ASM Lithography Inc., which is jointly owned by Netherlands companies N.V. Philips and Advanced Semiconductor Materials Inc. According to Ruddell, ASM currently makes "the best stepper [that] will do submicron technology." Both Philips and Siemens use ASM's steppers in their efforts to catch up with the Japanese in RAMs.

Because X-ray is still in its infancy, competition is limited. Hampshire Instruments Inc., based in Marlborough, Mass., is currently the only surviving start-up in X-ray lithography. Other companies that are continuing research in this field include IBM, Karl Suss KG GmbH & Co., based in West Germany, Nikon and Perkin-Elmer.

The field of competition is a bit more crowded in the more mature direct-write E-beam arena. For use in mask or reticle making, Perkin-Elmer's MEBES systems account for 82% of the 1986 market worldwide. In direct wafer exposure, Japan's JEOL Ltd. dominates with 45% of the 1986 market, according to VLSI Research. Other competitors include ASM International, Cambridge Instruments Inc., Hitachi Ltd. and Perkin-Elmer.

COST OF ENTRY

If staying in the microlithography market is extremely difficult, entering it is next to impossible. It is not uncommon for a start-up to spend five years and \$50 million to get its product to market, only to fail before shipping production volumes. The reasons for failure vary from addressing a technology too early or too late, running out of funding before project completion or coming to market during a recession.

Digital Automation Corp. (DAC),



NIKON's GIL VARNELL: Dependable equipment and fastidious attention to support have put Nikon on top

based in Burlington, Mass., is an example of one company that had considered entering this marketplace but was discouraged by the huge investment required to get a machine to market. DAC had been using computer-aided design tools to assist lithography equipment vendors in im-

Companies as well as governments continue to spend heavily in the push to make X-ray a viable technology for lithography

chines. Using those CAD tools, "it appeared we could design a breakthrough optical lithography machine," says Nicholas Mango, DAC president. But the company decided the costs of entering the market were prohibitive, Mango adds.

Others opted to forge on. In the still experimental area of X-ray lithography, an estimated \$26 million was invested in Micronix Corp. before the Los Gatos, California-based company folded. Tobey of ACT International, who was also a Micronix executive, estimates that when the company was in full swing, it was spending money at a "burn rate of between \$500,000 to \$600,000 a month."

Meanwhile, Hampshire Instrument has one piece of equipment being used in pilot line production, according to Darryl Peters, director of applications and metrology at Hamp-

shire. While Peters would not reveal how much funding has been poured into Hampshire, he suggests that it can cost \$30 million to bring an X-ray lithography tool to the beta testing stage.

Companies as well as governments continue to spend heavily in the push to make X-ray a viable technology for lithography. "A few hundred million dollars are currently being poured into X-ray by IBM and by companies in Japan and in Germany," according to Tobey. Some of those companies include Canon, Fujitsu Ltd., Hitachi, Matsushita Electric Industrial Co., NEC Corp. and NTT in Japan; IBM in the United States; and Philips, Siemens, and Karl Suss in Europe. In Tobey's mind, there's no doubt that "X-ray is the technology that will take us beyond what photolithography can do."

In the other post-photolithography camp, however, are the believers in direct-write systems. Most of them are betting on E-beam technology, which has also consumed a bundle but has yielded few results. Considering the estimates of VLSI's Hutcheson — development costs for a state-of-the-art E-beam machine can run in excess of \$100 million — it's not surprising that there are no start-ups in this market.

Price tags for E-beam direct wafer exposure systems are in the \$5 million range, and operating speeds are significantly slower than those of optical systems. The two current market applications are for low-volume ASIC devices, where savings in reticles make up for the machine price, or for prototyping devices, where fast turnaround is essential, says Stephen Reber, director of lithography for Perkin-Elmer's Connecticut operations. One example of an E-beam user is ASIC maker European Silicon Structures. According to Reber, European Silicon makes highly customized circuits; for its needs, E-beam direct wafer exposure equipment has proven to be cost effective. For high-volume users, however, cost and speed will have to improve. "If it [E-beam] weren't so slow and expensive, a lot of people would use it," says Arnold of AMD.

GCA's Simone roughly estimates that for 4Mb DRAMs on 6-inch wafers, E-beam would do well to produce three to five wafers an hour, compared with 40 to 45 for an optical system. GCA, along with Varian and Veeco Instruments Inc., invested millions of dollars in E-beam equipment

development before dropping out.

Indeed, in the world of lithography equipment manufacturing, funding is a major issue. Some, like ASM Lithography, Canon and Nikon, can be carried by multibillion dollar parents when the profits are nil. For example, Paul Henry, director for marketing at ASM Lithography, points out: "Our parent [N.V. Philips], has invested billions of dollars over the past few years to improve its position in the semiconductor industry... trying to get its level of expertise up to that of the Japanese and Americans. We are part of that investment."

Other companies are either at the mercy of investors or must depend upon internal resources. Because of the tremendous initial investment required — \$30 million to \$50 million — the risk that there might never be a return on that investment, and the amount of time it takes to actually sell equipment at production levels, it's almost impossible for any new company to break into the microlithography market.

If a company has a really excellent name or technology, then "with great difficulty" they might be able to raise the money, says John Turner, a managing partner with investment firm Techno-Venture Management in Boston. It is also possible to spend double-digit millions on product development, have good success in the marketplace, and yet not make any

money. Ruddell of Ruddell Associates questions whether or not anyone in the stepper business is really making any money. He even goes so far as to predict that, "10 to 15 years from now most merchants will be gone." Unless the industry can make equipment profitably, he adds, "the IBMs, GM Delco Electronics, Rockwells etc., will have to go out and buy these companies, and count the equipment as a part of overall manufacturing costs."

THE OBSTACLES

Where does all the money go? Why is it difficult for even the market leaders to make money? "Production development time is almost as great as product life cycles. It takes about two years to bring a new product to market, and it only lasts for two to three years," says Henry at ASM. In addition, he points out, research and development costs, which average between 15% to 20% of sales, are "well above the national average in business."

There are a number of things that eat up production dollars in wafer steppers, from the optics, to mechanics, to electronics to software. The materials alone in a wafer stepper cost several hundreds of thousands of dollars, says Tobey of ACT International. For example, a laser can cost \$25,000 to \$50,000 and a lense can

cost from \$35,000 to \$40,000, Tobey estimates.

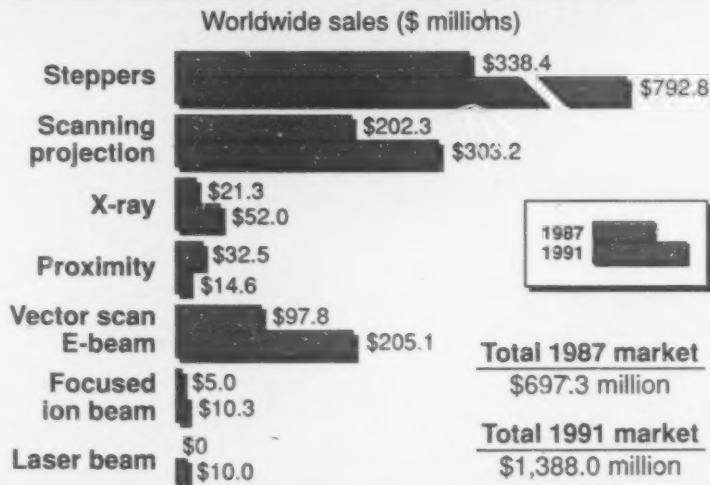
Indeed, every player must excel in not one technology, but several. To build and design a stepper, one must be at the leading edge not only in optics, but in software, vision and alignment, precision measurement and precision mechanics, details Simone of GCA. And then, once a system is built and gains market acceptance, "support costs are substantial," Simone adds. Vendors must offer service around the clock. They must also provide a great deal of application support. And, because this is a globalized market, he adds, "you have to participate in 22 countries and must be indigenous in every country."

The history of now-defunct Micronix illustrates the difficulties of a lithography start-up. During its years of operation, from 1981 to 1987, the company spent in excess of \$26 million, estimates Tobey, who is also a former Micronix executive.

After shipping its first three systems to customers in Japan for use in R&D, Micronix realized changes had to be made before it could interest U.S. customers, who wanted a production machine. Also, unexpectedly, developments in conventional optical steppers pushed the need for X-ray further out. And, as with any company working in X-ray microlithography, there were additional issues to be resolved. Besides the actual system, the company had to develop special X-ray masks and a better alignment system than what was used with conventional steppers. Also, a faster resist specifically built for X-ray sourced lithography was needed.

By 1986, the dollar was falling and orders expected from Japan dried up. A lot more money and a few more years were needed to get the product to the point at which it could be useful in production, says Tobey. By the first quarter of 1987, Micronix was looking for more dollars either through increased orders or equity investments or a corporate partner. In the third quarter of 1987, the company ceased operations. "We had an excellent team of people. The hardware was done," notes Tobey. "But when the dollar declined and the potential sales dried up in Japan, our schedule of need did not fit the availability of dollars." He goes on to say that, "there is no small, privately funded company that can possibly do it all." What's needed, he says, "is an equity partner, someone with deep pockets."

In the world of microlithography, steppers reign supreme through 1991



Source: VLSI Research Inc.

TAPE DRIVES

Why tape makers love to hear those hard disks crash

Quarter-inch tape drives are clear favorites for the data backup that is fast becoming essential for small computers

By Brian Deagon

The outlook for manufacturers of tape drives that use quarter-inch data cartridges is getting rosier all the time. After years of trying, they are finally getting the business they've long sought from major computer companies.

"We have been looking at other technologies, but quarter-inch tape makes the most sense for now," says Marti Hayes, tape drive product manager for Prime Computer Inc. "They make the most sense from the viewpoint of size and cost." Prime integrates 60-mega-byte tape drives into its three desktop multiuser computer systems.

And 3Com Corp., which began using quarter-inch tape drives in its local-area network systems three years ago, plans to continue doing so, says Charles Leis, server manager engineer. He notes that integrating the drives is much easier now than when they started. "We had major problems getting them running at first," he says. One problem was a lack of software development, an issue that has since been resolved.

Although half-inch reel-to-reel tape drives have been used as data storage devices for more than 25 years on mainframe computers, the use of the smaller quarter-inch tape drives only blossomed after

it became clear that microcomputers needed a more powerful backup device than floppy diskettes.

Despite the introduction of quarter-inch tape technology by 3M Co. in 1971, product acceptance was next to nil because the tape drive manufacturers failed to respond quickly enough to key issues, such as the need for smaller, faster, cheaper, compat-

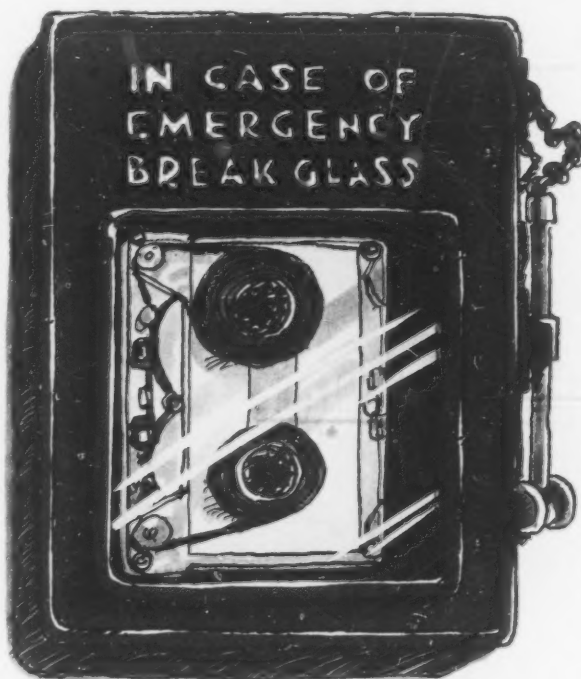
ible and more reliable products. This failure to respond gave OEMs and system integrators the jitters.

Much of that has changed, however. Computer makers will integrate more quarter-inch tape drives into microcomputers and minicomputers this year than ever before, analysts say. The list of manufacturers increasing their commitment to quarter-inch tape includes AT&T, Compaq Computer Corp., Honeywell Inc., Prime Computer Inc. and Unisys Corp.

In addition, IBM has been evaluating quarter-inch tape drives for several months for use in its Personal System/2 product family, and is expected to introduce new products sometime this year, industry sources acknowledge.

Indeed, 1987 is cited as a watershed year for the quarter-inch tape drive industry. It was the first year that shipments exceeded 1 million drives, according to Freeman Associates Inc., a Santa Barbara, California-based market research firm which closely monitors the tape drive industry. During calendar 1987, more than 2.3 million units will have been shipped worldwide. By comparison, less than 30,000 drives were shipped in 1982.

Annual worldwide revenue is expected to increase to \$759 million in 1987, from \$496 million in 1986, Freeman projects. "The quarter-



In case of disk crash, don't call floppies. Tape is becoming the emergency back-up of choice for PCs with over 40MB on disk

inch tape drive industry feels secure as a major growth industry for the rest of this decade," says Freeman Associates president Raymond Freeman Jr.

Previously, the industry outlook was not so good. In the early 1980s, the people who might use tape backup viewed the product as another form of insurance, but nothing mandatory.

What spurred the industry on was the growing use of hard disk drives in microcomputers and multiuser systems. The disk drives got smaller while the amount of data they could store grew higher. A bevy of microcomputers and multiuser systems is now now shipped with 40MB and 60MB hard disk drives and higher, all of which fit the 5.25-inch form factor.

At disk drive capacities above 20MB, using floppy diskettes as a backup device is about as practical as a four-cylinder engine in a race car. The demand for an inexpensive backup device is shooting up and low-end tape drives are best positioned to capture the greatest market share, analysts say. "The demand for quarter-inch tape drives coming from our computer system vendors and third party distributors is well ahead of last year," says Steve Malisewski, marketing vice president for Microage Computer Stores Inc., an international value-added dealer. He says the increase in demand is related to the fact that today's microcomputers are far more powerful than those being offered just three years ago.

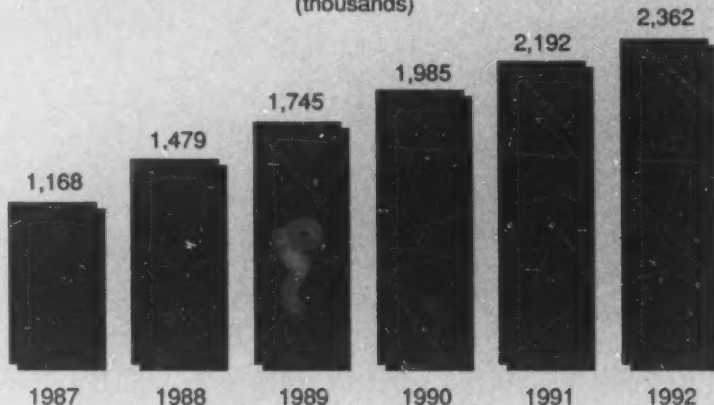
The increased demand for tape drives came only after unprecedented cooperation between the competing tape drive manufacturers, however. Tape drive companies were a scattered lot until 1982, when they united under the banner known as Quarter-Inch Compatibility Working Group. QIC outlined a set of standards designed to insure that the drives would record and transmit data in a manner that was compatible from one manufacturer's tape drive to the next.

The plan apparently worked. Tape drive shipments doubled in 1984 and more than doubled in 1985. Currently, more than 30 low-end tape drive manufacturers offer more than 100 classifications of tape drives, says Freeman. More than half of those companies are based in the United States.

The industry joined hands again in 1986 and embarked on a nationwide educational and advertising cam-

1987 was the first year quarter-inch tape drive shipments exceeded 1 million units

Worldwide unit shipments of quarter-inch data cartridge tape drives (thousands)



Source: Freeman Associates Inc.

paign designed to drive home the idea that quarter-inch tape should be used to back up data on microcomputers and LANs. "We invested lots of dollars to tell everyone who had a PC with a 20MB disk drive or higher that they need to secure their data with a backup device," says Charles Calisto, 3M Co. marketing manager for data cartridge products. Citing research, Calisto says that filling a 20MB hard disk drive takes about one month and can cost upward of \$50,000 to replace if that information is somehow deleted or lost due to disk crash or user error.

Tape drive companies also cooperated on a direct mail campaign that

gesting huge amounts of data. As a result, "backup is no longer an option — it's a necessity," says Norm Weinberg, director for marketing and distributor sales at Wangtek Inc., a tape drive manufacturer.

Tree rattling

"At capacities of 20MB and below, you can still use a floppy to store data. But when you go beyond 40MB, a user can't afford to lose that data," says Weinberg. The quarter-inch tape drive industry had its tree rattled last April when IBM introduced a write-once, read-many times (WORM) optical disk for use as a data storage and retrieval device. But optical WORM drives are receiving only lukewarm reception for now because no one has introduced erasable optical media — a crucial step if the product is to be taken seriously, many analysts agree.

Another technology waiting in the wings is digital audio tape, which uses a helical scan recording head that is able to record data on tape at densities well above current quarter-inch tape technology. Digital DAT drives could compete with quarter-inch tape and become an industry standard for data storage in the 1990s if interface and format standards are resolved, says Lee Elizer, president of Peripheral Strategies Inc., a Santa Barbara-based market research company.

Only one manufacturer — Exabyte Corp. — is currently shipping low-end helical scan tape drive products for data storage. But Hewlett-Packard Co. and Sony Corp., among several other well-heeled companies, are

Tape drive shipments doubled in 1984 and more than doubled in 1985

delivered 4,500 promotional packages to management information systems directors, data-processing managers and the like. Almost 20% responded for more information, says Calisto.

The need for a unified tape community is spurred partly by the encroachment of other manufacturers touting newer technologies to replace quarter-inch tape as a standard backup device. The designers of computer storage devices have long recognized that desktop publishing systems, PC workstations and CAD/CAM systems and other powerful 80386-based microcomputers are di-

studying DAT technology. Where those efforts will end up, it is too soon to tell. Still, Exabyte announced more than \$25 million in sales to OEMs, VARs and system integrators in its first year.

Another threat to quarter-inch tape comes from developers of low-end tape drives that use the half-inch tape cartridges endorsed by IBM, called the 3480. But this, like the other competing technologies, is still in fledgling stages of development and is not endorsed by major manufacturers to the degree that quarter-inch tape has been.

A further challenge to quarter-inch tape technology is posed by makers of low-cost tape drives that use audio-sized cassettes to store data. This group of manufacturers, which includes TEAC Corp. and Eastman-Kodak Co. subsidiary Verbatim Co., has also banded together to standardize its products. But they have been slow to promote their products aggressively and may soon find themselves trailing in the tape drive sweepstakes if more action isn't taken soon, analysts note.

In the meantime, the quarter-inch tape drive industry is taking every step possible to cover its flanks. For instance, QIC recently incorporated as a trade association, which means it will be able to elect a staff of people to conduct more aggressive marketing, do cooperative advertising, offer more seminars and distribute literature to promote quarter-inch tape technology.

Another sign of the industry's maturation was its quick redesign of tape drives to fit the emerging 3.5-inch industry standard form factor. In 1987, Freeman forecasts that the tape drive industry will have shipped 492,000 tape drives that can fit the 3.5-inch form factor, compared to none in this class less than four years ago.

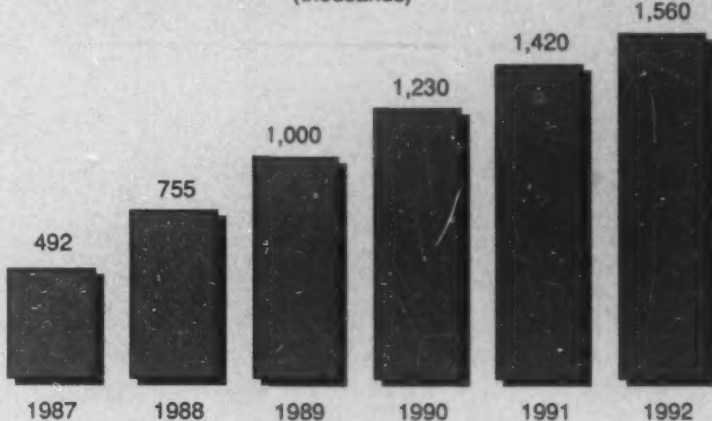
Boost from Apple

The outlook for these tiny quarter-inch tape drives was given a major boost last year when Apple Computer Inc. announced it would support the product on its new line of Macintosh II and SE microcomputers. This class of drives will exceed 1.5 million units shipped in 1992, a 36% annual growth rate from the 250,000 units shipped in 1986, says Freeman.

Tape drive manufacturers have demonstrated an ability to shrink the product while they increase data storage capacities — key issues if they

The 3.5-inch tape drive market did not even exist less than four years ago

Worldwide unit shipments of 3.5-inch minicartridge tape drives (thousands)



Source: Freeman Associates Inc.

are to remain the storage device of choice at the low end. Products now being shipped range up to 125MB and 150MB capacities. But three Southern California-based companies — Archive Corp.; Siemens AG subsidiary Tandberg Data Inc.; and Wangtek — say that this year they will ship quarter-inch tape drives which store 320MB. It does not stop there: 3M recently announced plans to ship a 1-gigabyte quarter-inch tape drive by late 1989.

The California trio comprises, along with Cipher Data Products Inc., the leading tape drive manufacturers. Two other companies also cited for tape drive development are Alloy Computer Products Inc. and Irwin Magnetic Systems Inc. Their collective push into products that store hundreds of megabytes appears to be what OEM customers want: "We're anxious for higher capacity tape drives," says 3Com's Leis.

"There is a much greater appreciation for tape backup today than there was a year ago," says Frank Kirchoff, director of computer distribution for Microlynx Inc., a Torrance, California-based distributor of PCs and peripherals. "We consider tape backup to be a commodity product now. Pricing has gotten very competitive and portability and compatibility issues have been resolved," he notes.

Microlynx sells a 60MB, quarter-inch drive made by Cipher Data for a list price of \$990. About two years ago, that same drive cost about \$1,500. The increased demand for products has allowed manufacturers

to achieve greater efficiencies in manufacturing, thus lowering costs.

Computer retailers are enthusiastic too. "The time has come for quarter-inch tape drives," says Dennis Kemmerer, product research analyst for computer retail chain Businessland Inc. "People are less willing to back up data on floppies due to the amount of time it takes," he adds. Businessland has been studying other data backup devices, including optical disk drives and digital audio tape. But, says Kemmerer, "what has inspired us toward quarter-inch tape drives is the increased functionality of software and the network compatibility."

Most leading computer retail chains and distributors now carry quarter-inch tape drives in their inventory, notes Whitney Lynn, chief operating officer of Tecmar Inc., which markets quarter-inch tape drives mostly through third-party channels. He says companies that now use quarter-inch tape as a standard backup device routinely include Atlantic Richfield Co. (ARCO), General Dynamics Corp., GTE Corp., Mobil Oil Corp. and Universal Studios. About 15% of all microcomputers with a hard disk drive above 20MB are equipped with a quarter-inch tape drive, analysts say. Less than two years ago, about 5% of users had a quarter-inch tape drive.

Tape drive makers view this acceptance as a critical step if quarter-inch tape is to compete with and surpass other backup technologies on the horizon. □

COMPUTERS

Will Honeywell Bull survive its inheritance?

The multinational computer maker is cutting capacity and reducing staff as it searches for a valuable niche

By Steve Gross

Honeywell Bull is cutting back on people and production a year after its birth.

Formed in March 1987 by Honeywell Inc. of Minneapolis, Groupe Bull of France and NEC Corp. of Japan, Honeywell Bull consists mainly of what were once the operations of Honeywell Information Systems.

That division, however, never found a substantial niche in the U.S. computer market, and analysts say that if Honeywell Bull is to survive, it must find one fairly soon. The latest changes, analysts add, are a step in the right direction.

Paring the payroll

Last November, Minneapolis-based Honeywell Bull announced a major cutback in the U.S. operations it inherited from Honeywell. It disclosed plans to trim 1,600 U.S. workers from the 20,500 worldwide employee payroll; close a large computer factory in Phoenix; and consolidate manufacturing operations in Lawrence, Mass., all over a 12-month period beginning that November. A consolidation of company offices in Billerica, Mass., was slated to occur over an 18-month period, also from November.

The workforce reductions will include about 800 people in the firm's 3,100-employee Phoenix operations, where large computer development and other nonmanufacturing operations will remain; 500 in the 4,700-employee Boston area operations; and 300 others in sales offices across the country.

That means that about 1,000 jobs will be eliminated in manufacturing and related support services, and that 600 will be cut in marketing, sales, service and other areas, the company says. But, at the same time, Hon-



HONEYWELL BULL's MEYER says the company will cut 1,600 jobs to reduce administrative costs and unneeded production capacity

eywell Bull has plans to add about 250 people in software development, field sales and field technical support.

The cuts are twice the size of the 800-employee reduction that Honeywell made in its computer business in 1986, a few months before spinning it off as a joint venture. Honeywell Bull president Jerome Meyer says the layoffs are designed to solidify the company's 3% share of the worldwide minicomputer and mainframe market by reducing U.S. administrative costs and eliminating unneeded production capacity. The changes won't affect the company's international operations, Meyer says, because those divisions don't have excess employment or factory capacity.

Another change at Honeywell Bull involves giving its U.S. regional sales vice presidents more responsibility to improve performance, Meyer says. That part of the reorganization "is

geared to get people closer to the customer," by putting more profit-and-loss responsibility in the field, he adds.

Donald Bellomy, an analyst at International Data Corp. in Framingham, Mass., says the changes in marketing and sales responsibility are, in effect, a shake-up. "When you move profit-and-loss responsibility closer to the people who are making sales, you often make them more nervous and more motivated," he says.

The reductions in employment and factory space, Bellomy adds, reflect the longtime inability of the computer operations, under their old Honeywell management, to build market share in the United States. Unlike the other BUNCH companies, including Control Data Corp. and the Burroughs and Sperry corporations, now Unisys Corp., Honeywell never developed a strong niche for its computer business, he says. As a result, he estimates that Honeywell Bull's share of the market in minicomputers, superminicomputers and mainframes totals only about 2.5%.

"I think Honeywell Bull is still looking for a niche. They want to exploit what had been a growing strength toward systems integration. The difficulty that they would have at this point is that the real expertise in integration at Honeywell Information Systems was in the federal systems operation which Honeywell kept," Bellomy says.

But Honeywell Bull's Meyer says the changes were announced at a time when the computer maker was doing well. While he declined to provide earnings figures for the privately owned firm, Meyer says Honeywell Bull will be marginally profitable on revenue of \$2.1 billion in fiscal year 1987. Revenue was up about 10% in 1987 in relation to comparable operations of the three parent companies

in 1986, he says.

Meyer says the U.S. market accounts for about half the revenue of the company, in which Honeywell and Bull each own 42.5% and NEC owns 15%. International operations include about \$500 million worth of business in Italy; \$250 million in Britain; \$100 million each in Canada and Australia; and about \$50 million in Mexico and the Far East, he says.

Cutting capacity

Ulric Weil, a Washington, D.C.-based analyst with his own firm, says the former Honeywell computer operations "clearly were overstaffed. This goes back years, and Honeywell has never been willing to bite the bullet. Once they were willing to sell [the computer business] off, they let someone else do that unpleasant chore."

A Honeywell spokeswoman declined to comment on Weil's assertion. But Meyer, who was head of Honeywell Information Systems, defends Honeywell and says the company would have dealt with the problems of too many employees and factories had it not been for the more immediate job of creating Honeywell Bull. "Honeywell was prepared, I think, to take action," he says. "But I think the formation of the new company and getting it started caused the situation to be slowed down."

Meyer maintains that the overstaffing situation is partly based on the technological changes that have occurred in computer manufacturing since most of the former Honeywell computer plants were established in 1975.

"Technology has allowed you to produce an awful lot of power with a lot fewer manufacturing facilities," Meyer says, but Honeywell hadn't reduced its computer factory capacity significantly since 1975.

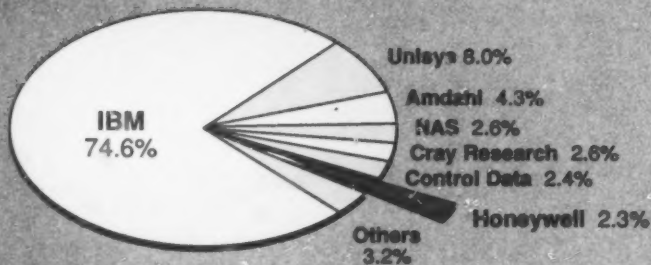
The company's U.S. computer factories have been about 50% underutilized, according to Meyer, and the reductions will cut that to about 20%, allowing room for growth. If more manufacturing capacity is needed in the future, Honeywell Bull can get it from its British plant or from Bull and NEC factories abroad, he says.

On the heels of the announcement, Frank Allen, an analyst with Arthur D. Little in Cambridge, Mass., says the changes at Honeywell Bull reflect a shift in emphasis from manufacturing to sales. In the long run, he predicts, Honeywell Bull will delegate more of its manufacturing to NEC.

Meyer disputes that. He says there

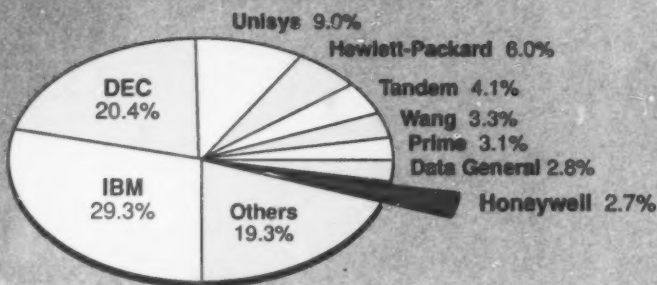
Honeywell Bull inherited last place in the 1986 worldwide mainframe and mini markets

Large-scale systems



Total 1986 market: \$17.6 billion

Medium-scale systems



Total 1986 market: \$15.0 billion

Source: International Data Corp.

isn't any plan to shift manufacturing to Bull or to NEC. For one thing, Meyer observes, the weak U.S. dollar doesn't favor moving manufacturing out of the United States.

IDC's Bellomy agrees. In addition to the unfavorable yen-dollar relationship, says Bellomy, the company might lose some potential U.S. government sales if it sold more Japanese-made machines. "Honeywell Bull is very aware of the difficulties that this can create in today's environment," Bellomy adds. One way around that, he suggests, would be for Honeywell Bull to produce future high-end mainframes in the United States under license from NEC.

But NEC probably isn't all that interested in playing a larger role in Honeywell Bull, Bellomy says. "What Honeywell Bull gives NEC is distribution, and therefore economies of scale for its high-end mainframes. Essentially the 15% [ownership of Honeywell Bull] NEC came in at is enough to make sure they continue to have a distribution channel, but not enough for them to have to worry about getting involved in day-to-day or month-to-month decisions about what's going on."

But whether or not it has to look to its parent firms for help, Bellomy says he believes Honeywell Bull has a three-year window in which it can try to find a niche in the U.S. computer market.

If the changes that have been made in U.S. operations don't provide a turnaround by then, "Honeywell Bull and Bull will become a European-based company working out of Paris," Bellomy predicts. If such an arrangement became necessary, Honeywell Bull probably would become a minor U.S. marketing organization for its European parent, he concludes.

But Honeywell Bull does have two big advantages that didn't exist when the computer operations were being run by Honeywell, Bellomy says. Honeywell Bull is exclusively focused on the computer business, while Honeywell was more diversified, and it is a private company that is under less pressure to produce financial results than a public company like Honeywell.

"There's always some doubt that Honeywell Bull will make it," Bellomy says. "But their chances are better than those of Honeywell Information Systems." □

COMPUTER BUSINESS

DATABASE

A crashing halt

New orders for computers and office machinery came to a crashing halt in November, the first month after Black Monday. The \$4.1 billion in new orders was down 18.5% from the previous month on a seasonally adjusted basis.

Shipments, which previously had been on the rise, fell 13.2% from October to November. The \$4.3 billion value for November was the lowest monthly figure since December of 1983. Inventory, increasing 2.4% from month-to-month, absorbed the production overflow, pushing the November inventory/shipment ratio to 2.29, up from the 1.94 in October.

Monthly trade figures for October were disappointing given the large depreciation of the U.S. dollar. Exports of office and computing machines fell from \$1,730.8 million in September to \$1,693.5 million in October. By contrast, imports rose 26.7% to \$2164.1 million in October. Though the trade tide has yet to turn, U.S. computer manufacturers have gained significant price advantages. From March 1985, when the value of the dollar peaked, to September 1987, the price of U.S. computers and business equipment, measured in foreign currency, plummeted 33%. Meanwhile, the price of imported units measured in U.S. dollars rose 19%.

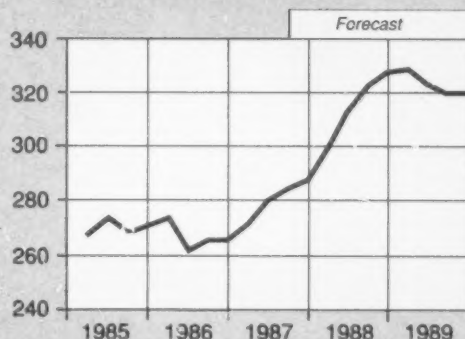
Edited by LINDA STALLMANN

More information can be obtained from Madeline Franchi, senior economist, Cahners Economics Department, 275 Washington St., Newton, MA 02158 Phone: (617) 964-3030.

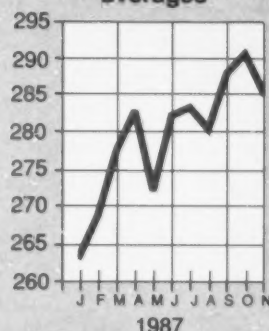
Industrial production index for computers

Seasonally adjusted index (1977=100)

Quarterly averages



Monthly averages

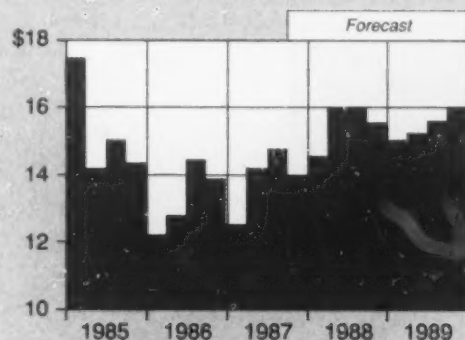


Source: U.S. Department of Commerce; Forecast: Cahners Economics

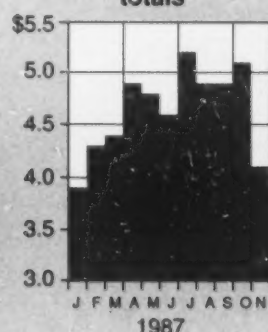
New orders of computers

Seasonally adjusted (Current \$ billions)

Quarterly totals



Monthly totals



Source: U.S. Department of Commerce; Forecast: Cahners Economics

Computer market database

	Latest month	Previous month	Change	Year ago	Change	Next year	Change
Industrial production (SA, 1977=100, November)	286.1	291.19	-1.7%	265.38	+7.8%	333.58	+16.6%
Shipments (SA, \$ millions, November)	\$4,275	\$4,927	-13.2%	\$4,562	-6.3%	\$5,407	+26.5%
New orders (SA, \$ millions, November)	\$4,116	\$5,053	-18.5%	\$4,798	-14.2%	\$5,228	+27.0%
Unfilled orders (SA, \$ millions, November)	\$19,162	\$19,321	-0.8%	\$19,302	-0.7%	\$21,087	+10.0%
Inventory-to-shipment ratio (SA, November)	2.29	1.94	—	2.21	—	1.97	—
All employees (thousands, November)	462.3	460.1	+0.5%	463.09	-0.2%	492.37	+6.5%
Production workers (thousands, November)	152.3	151.1	+0.8%	153.5	-0.8%	159.93	+5.0%
Exports (\$ millions, October)	\$1,694	\$1,731	-2.1%	\$1,434	+18.1%	\$1,798	+6.1%
Imports (\$ millions, October)	\$2,164	\$1,708	+26.7%	\$1,621	+33.5%	\$1,775	-18.0%

SA = seasonally adjusted, all other data is not seasonally adjusted

Data sources: Federal Reserve Board, U.S. Bureau of the Census and U.S. Bureau of Labor Statistics
All data for SIC 357, except industrial production, SIC 357-9. Forecasts: Cahners Economics

LETTERS

The Apple of their eye

The article in the Nov. 15 issue of **ELECTRONIC BUSINESS** entitled "A tasty treat for board makers: It's Mac tonight" [p100] discusses the new open architecture Macintosh PCs and the reaction of various board vendors to this new opportunity. I was amazed and disappointed that National Instruments was not even mentioned in your article.

At Apple's invitation, National Instruments participated in the Apple-World show on April 2, 1987, where the Macintosh II and Macintosh SE were announced by Apple. At that show, National Instruments announced a family of seven sophisticated data acquisition plug-in boards for the Macintosh II and Macintosh SE. National Instruments was the featured plug-in hardware vendor at the show and surprised everyone with the coordinated introduction of an entire line of plug-in boards.

While other companies are evaluating the open architecture Macintosh family to decide what to do, we are shipping product in volume and al-

ready have a substantial installed base in applications including automated test and measurement, laboratory automation, chemistry, sound and vibration, biomedical, process control, calibration and communications.

RON WOLFE
Product Planner
National Instruments
Austin, Texas

Corrections

The source listed for a chart of the top database management system software vendors in the Nov. 1, 1987 issue [p68] was incorrect. The source was International Data Corp.

The contract manufacturing directory in the Dec. 10 issue should have included the following two companies:

Express Manufacturing Inc.
Chauk P. Chin
3115 W. Warner Avenue
Santa Ana, Calif. 92704
Phone: (714) 556-1878
Employees: 230

Computers and peripherals. Static-controlled electronic contract manufacturing for

leaded, SMT, and mechanical assembly

Manutek Inc.
Steven D. Smith
8076 Woodland Drive
Indianapolis, Ind. 46278
Phone: (317) 872-9737
Revenue: \$6.5 million
Employees: 100

Computers and peripherals; industrial; instrumentation and medical; consumer and automotive; and military. Prototype, low-and high-volume printed circuit board assembly. Through-hole and SMT; cable and wire harness assembly; engineering design; full-service purchase and material control

The market charts on pages 92 and 94 in the Jan. 1, 1988 issue incorrectly identified the revenue base. Revenue was for the U.S. market.

The Jan. 1, 1988 issue incorrectly reported that Universal Semiconductor and California Devices Inc. had withdrawn from the ASICs business ["The ASIC market: Paradise yesterday, war zone today"]. Efforts were made to ensure the validity of the data reported, which was supplied by two market research firms.

Investing? — Yes, in Nova Scotia!

Why don't you come and see for yourself that Nova Scotia is a good place to live, work and invest.
Pratt & Whitney, Litton and Michelin did.

"There were several reasons why Pratt & Whitney located its new plant in Nova Scotia. First and foremost, was the availability in Nova Scotia of a large pool of manpower that could be trained easily to work in our facility and also, a very enthusiastic response from the governments of Nova Scotia and Canada to work with us to develop a very large training program to make it happen."

Gilles Ouimet, Senior Vice President-Operations, Pratt & Whitney Canada Incorporated

Litton Canada's decision to locate in Nova Scotia was based on the availability of a dedicated workforce, dependable supply of services, an efficient transportation network, quality education facilities and, above all, a cooperative and supportive government. All the important factors that contribute to the long term viability of a modern company.

O. K. MacLean, Director, Special Projects
Litton Systems Canada Limited

Michelin began tire production in Nova Scotia in 1971. Since then our employees have proven they can compete for high quality tire markets around the world.

We work together to produce Michelin Tires made in Nova Scotia with a quality of workmanship that keeps us on the leading edge of our industry. Our progress is a result of employees' efforts, and we will continue to progress as we all strive to reach our maximum potential in our Nova Scotia plants.

Alain Redheuil, Vice-president, General Manager, Michelin Tires (Canada) Limited

For more information on:

Industrial Regional Development Incentives
Investment Tax Credit
Research and Development Tax Credit
and many other programs available in Nova Scotia.

Contact:

Nova Scotia Department of Industry,
Trade and Technology
1800 Argyle Street, P.O. Box 519
Halifax, Nova Scotia
Canada, B3J 2R7
Telephone (902) 424-5320
Telex 019 22548
or Atlantic Canada Opportunities Agency
Telephone (902) 426-8361
Fax (902) 426-2054

Nova Scotia



Canada